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Debris/Ice/TPS Assessment And Photographic Analysis For Shuttle Mission STS-43

Gregory N. Katnik
NASA/Kennedy Space Center

Scott A. Higginbotham
NASA/Kennedy Space Center

J. Bradley Davis
NASA/Kennedy Space Center

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DEBRIS/ICE/TPS ASSESSMENT
AND
PHOTOGRAPHIC ANALYSIS
OF
SHUTTLE MISSION STS-43

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Prepared By:

Scott A. Higginbotham
NASA/Kennedy Space Center
TV-MSD-22

J. Bradley Davis
NASA/Kennedy Space Center
TV-MSD-22

Approved:

Gregory N. Katnik
Lead, Ice/Debris/Photo Analysis
NASA/Kennedy Space Center
TV-MSD-22

Pedro J. Rosado
Chief, ET Mechanical Sys
NASA/Kennedy Space Center
TV-MSD-22

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FOREWORD

The Debris Team is continuing its effort to develop and implement measures to control damage from debris in the Shuttle operational environment and to make the control measures a part of routine processing and operations.

Shuttle Mission STS-43 was launched at 11:02 a.m. local 8/2/91

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1.0 Summary

The STS-43 pre-launch inspection of the pad and Shuttle vehicle was conducted on 23 July 1991. The detailed walkdown of Launch Pad 39A and MLP-1 also included the primary flight elements OV-104 Atlantis (9th flight), ET-47 (LWT-40), and BI045. There were no vehicle anomalies. Minor facility discrepancies were resolved prior to cryoload.

The launch was scrubbed due to a failure in the SSME #3 Digital Computer Unit (DCU). The LH2 and LO2 tanks had been filled to 100 percent (stable replenish). A post-drain walkdown of the SSV and the MLP revealed no significant anomalies.

A second pre-launch debris inspection of the pad and Shuttle vehicle was conducted on 31 July 1991. There were no vehicle anomalies. Minor facility discrepancies were resolved prior to cryoload.

Orbiter SSME #3 DCU was replaced and the vehicle was cryoloaded for flight on 1 August 1991. During the topping phase of hydrogen tanking, leak detectors 23 and 25 showed a reading of 20,000 ppm hydrogen in the GUCP cavity purge. The leakage did not violate the Launch Commit Criteria of 4 percent maximum concentration. A facility IPR was taken against a liquid oxygen leak inside the LO2 TSM. The IPR was not a constraint for launch. There were no ET ice or debris conditions outside of the established data base. Light condensate, but no ice or frost, was present on the acreage areas of the External Tank. Five Ice/Frost Team observation/anomalies were documented and found acceptable for launch per the LCC and NSTS-08303. The LH2 umbilical leak sensor detected no significant hydrogen during the cryoload. The tubing was successfully removed from the vehicle with no TPS contact or damage.

The second launch attempt was scrubbed due to unacceptable RTLS weather conditions. The LH2 and LO2 tanks had been filled to 100 percent (stable replenish). A post-drain walkdown of the SSV and the MLP revealed no significant anomalies.

The vehicle was cryoloaded for flight on 2 August 1991. One hour into cryo load ten to fifteen drips with vapor trails fell from the aft part of the LH2 ET/ORB umbilical-to-recirculation line interface area. There was no evidence of a blowing leak, nor did the drips appear for a consistent, frequent, or extended duration. The drips fell below the field of view before completely vaporizing and behaved like liquid air rather than hydrogen. Since that area had just chilled down due to the start of recirculation, the source of the cryogenic drips was probably a small TPS void or defect that had cryopumped locally for a short period of time. No more cryogenic drips occurred for the remainder of cryoload, stable replenish, flight pressurization, and launch. The recommendation made by the Ice Team and accepted by Launch Team Management was to document the

event in OMI S6444 and that no IPR was required. There was no violation of OMRS S00FB0.360, which verifies no cryogenic leakage or excessive vapors from ET/ORB MPS areas.

During the topping phase of hydrogen tanking, leak detectors 23 and 25 again showed a 2 percent concentration of hydrogen in the GUCP cavity. The leakage did not violate the Launch Commit Criteria of 4 percent maximum concentration. Externally, there was no apparent leakage anywhere on the GH2 vent line or GUCP. Excessive GOX vapors again emanated from the open LO2 TSM door and condensate was present on the walls of the TSM. A facility IPR with no constraint to launch was still open against a liquid oxygen leak inside the LO2 TSM. There were no ET ice or debris conditions outside of the established data base. Light condensate, but no ice or frost, was present on the acreage areas of the External Tank. Five Ice/Frost Team observation/ anomalies were documented and found acceptable for launch per the LCC and NSTS-08303.

A debris inspection of Pad 39A was performed after launch. Two base heat shield Q-felt plugs were found at the southwest corner of the pad apron. No other flight hardware or TPS materials were found. Launch damage to the holddown posts was minimal. EPON shim material on the south holddown posts was intact. The GH2 vent line had latched properly.

A total of 146 film and video items were analyzed as part of the post launch data review. No major vehicle damage or lost flight hardware was observed that would have affected the mission. Pad films confirmed a stud hang-up on HDP #7. No ordnance fragments fell from the HDP #7 DCS/stud hole. Three ordnance fragments fell from the HDP #2 DCS/stud hole shortly after liftoff. One dark, thin object, possibly a frangible nut web or piece of firing cable, fell between the doghouse blast cover and the HDP #8 shoe. The new optimized frangible links were installed in the SRB DCS's for this mission.

A white object fell from the aft end of the Orbiter at T+42.844 seconds MET. The object, believed to be a section of the SSME closeout blanket, appeared to originate near SSME #2 and fell aft of the Orbiter before being lost against the SRB plume. Orbiter performance, landing gear extension, wheel touchdown and vehicle rollout after landing was nominal.

The Solid Rocket Boosters were inspected at Hanger AF after retrieval. Both frustums exhibited no missing TPS, but had a total of 84 debonds over fasteners. The field joint protection system closeouts were in generally good condition. The aft booster stiffener ring splice plate closeouts were intact and no K5NA material was missing. HDP Debris Containment System (DCS) plungers were seated with the exception of HDP #2, which was obstructed by a frangible nut half. This was the second flight utilizing the optimized link. Post flight disassembly of the DCS housings revealed an overall system debris retention of

92 percent. The HDP #7 aft skirt bolt hole was broached along the hole edge closest to the centerline of the SRB. EPON shim material adjacent to the broached edge was missing.

A detailed post landing inspection of OV-104 (Atlantis) was conducted on August 11-12, 1991, at the Kennedy Space Center on Runway 15 and in the OPF. The Orbiter TPS sustained a total of 131 hits, of which 25 had a major dimension of one inch or greater. The Orbiter lower surface had a total of 122 hits, of which 24 had a major dimension of one inch or greater. Based on these numbers and comparison to statistics from previous missions of similar configuration, the total number of Orbiter TPS debris hits was greater than average, and the number of hits with a major dimension of one inch or larger was near average. The largest single damage site on the Orbiter lower surface occurred on the RH nose area below the forward RCS module and measured approximately 18" x 1" x 1/8" (spanned 6 tiles). This shallow damage is typically caused by low density material, such as ET SOFI.

The ET/ORB separation ordnance device plungers were seated and appeared to have functioned properly. SSME #1 closeout blanket was missing numerous layers of material from 4:00 to 7:00 o'clock (approximately 40 inches in length) and may have been the white object observed in films falling aft of the Orbiter 43 seconds after launch. One piece of flight hardware was found on the runway beneath the LO2 ET/Orbiter umbilical. A metallic U-shaped object, identified as a V072-565471-001 yoke, originated from the LO2 umbilical forward inboard separation bolt head.

A variety of residuals were present in the Orbiter window samples and indicated sources such as Orbiter TPS, SRB BSM exhaust residue, natural landing site products, organics, and paint. The lower surface tile samples showed localized heating effects from re-entry. The residual samples recovered from the damage sites indicated tile TPS elements and a material variety similar to that observed in the window sample area. This data does not indicate a single source of damaging debris and all of the materials have been previously documented in post-landing sample reports.

A total of ten Post Launch Anomalies, including one IFA candidate, were observed during this mission assessment.

Overall, vehicle TPS subsystem performance and debris issues worked on the STS-43 mission were average compared to previous missions.

2.0 KSC ICE/FROST/DEBRIS TEAM ACTIVITIES

Team Composition: NASA KSC, NASA MSFC, NASA JSC, LSOC SPC, RI - DOWNEY, MMMSS - MAF, USBI - BPC, MTI - UTAH

Team Activities:

1) Prelaunch Pad Debris Inspection

Objective:	Identify and evaluate potential debris material/sources. Baseline debris and debris sources existing from previous launches.
Areas:	MLP deck, ORB and SRB flame exhaust holes, FSS, Shuttle external surfaces
Time:	L - 1 day
Requirements:	OMRSD S00U00.030 - An engineering debris inspection team shall inspect the Shuttle and launch pad to identify and resolve potential debris sources. The prelaunch vehicle and pad configuration shall be documented and photographed.
Documents:	OMI S6444
Report:	Generate PR's and recommend corrective actions to pad managers.

2) Launch Countdown Firing Room 2

Objective:	Evaluate ice/frost accumulation on the Shuttle and/or any observed debris utilizing OTV cameras.
Areas:	MLP deck, FSS, Shuttle external surfaces
Time:	T - 6 hours to Launch + 1 hour or propellant drain
Requirements:	OMRSD S00FB0.005 - Monitor and video tape record ET TPS surfaces during loading through prepressurization.
Documents:	OMI S0007, OMI S6444
Report:	OIS call to NTD, Launch Director, and Shuttle managers. Generate IPR's.

3) Ice/Frost TPS and Debris Inspection

Objective:	Evaluate any ice formation as potential debris material. Identify and evaluate any ORB, ET, or SRB TPS anomaly which may be a debris source or safety of flight concern. Identify and evaluate any other possible facility or vehicle anomaly.
Areas:	MLP deck, FSS, Shuttle external surfaces
Time:	T - 3 hours (during 2 hour BIH)
Requirements:	OMRSD S00U00.020 - An engineering debris inspection team shall inspect the Shuttle for ice/frost, TPS, and debris anomalies after cryo propellant loading. Evaluate, document, and photograph all anomalies. During the walkdown, inspect Orbiter aft engine compartment (externally) for water condensation and/or ice formation in or between aft compartment tiles. An IR scan is required during the Shuttle inspection to verify ET surface temperatures. During the walkdown inspect ET TPS areas which cannot be observed by the OTV system.
Documents:	OMI S0007, OMI S6444
Report:	Briefing to NTD, Launch Director, Shuttle management; generate IPR's.

4) Post Launch Pad Debris Inspection

Objectives:	Locate and identify debris that could have damaged the Shuttle during launch
Areas:	MLP zero level, flame exhaust holes and trenches, FSS, pad surfaces and slopes, extension of trenches to the perimeter fence, walkdown of the beach from Playalinda to Complex 40, aerial overview of inaccessible areas.
Time:	Launch + 1 hours (after pad safing, before washdown)
Requirements:	OMRSD S00U00.010 - An engineering debris inspection team shall perform a post launch pad/area inspection to identify any lost flight or ground systems hardware and resultant debris sources. The post launch pad and area configuration shall be documented and photographed.
Documents:	OMI S0007, OMI S6444

Report:	Initial report to NTD and verbal briefing to Level II at L+8 hours; generate PR's.

5) Launch Data Review

Objective:	Detailed review of high speed films video tapes, and photographs from pad cameras, range trackers, aircraft and vehicle onboard cameras to determine possible launch damage to the flight vehicle. Identify debris and debris sources.
Time:	Launch + 1 day to Launch + 6 days
Requirements:	OMRSD S00U00.011 - An engineering film review and analysis shall be performed on all engineering launch film as soon as possible to identify any debris damage to the Shuttle. Identify flight flight vehicle or ground system damage that could affect orbiter flight operations or future SSV launches.
Documents:	OMI S6444
Report:	Daily reports to Level II Mission Management Team starting on L+1 day through landing; generate PR's.

6) SRB Post Flight/Retrieval Inspection

Objective:	Evaluate potential SRB debris sources. Data will be correlated with observed Orbiter post landing TPS damage.
Areas:	SRB external surfaces (Hangar AF, CCAFS)
Time:	Launch + 24 hours (after on-dock, before hydrolasing)
Requirements:	OMRSD S00U00.013 - An engineering debris damage inspection team shall perform a post retrieval inspection of the SRB's to identify any damage caused by launch debris. Anomalies must be documented/photographed and coordinated with the results of the post launch shuttle/pad area debris inspection.
Documents:	OMI B8001
Report:	Daily reports to Level II Mission Management Team. Preliminary report to SRB Disassembly Evaluation Team. Generate PR's.

7) Orbiter Post Landing Debris Damage Assessment

Objective:	Identify and evaluate areas of Orbiter TPS damage due to debris and correlate if possible, source and time of occurrence. Additionally, runways are inspected for debris/sources of debris
Areas:	Orbiter TPS surfaces, runways
Time:	After vehicle safing on runway, before towing
Requirements:	OMRSD S00U00.040 - An engineering debris inspection team shall perform a prelanding runway inspection to identify, document, and collect debris that could result in orbiter damage. Runway debris and any facility anomalies which cannot be removed/corrected by the Team shall be documented and photographed; the proper management authority shall be notified and corrective actions taken.
Requirements:	OMRSD S00U00.050 - An engineering debris inspection team shall perform a post landing runway inspection to identify and resolve potential debris sources that may have caused vehicle damage but was not present or was not identified during pre-launch runway inspection. Obtain photographic documentation of any debris, debris sources, or flight hardware that may have been lost on landing.
Requirements:	OMRSD S00U00.060 - An engineering debris inspection team shall map, document, and photograph debris-related Orbiter TPS damage and debris sources.
Requirements:	OMRSD S00U00.012 - An engineering debris damage inspection team shall perform a post landing inspection of the orbiter vehicle to identify any damage caused by launch debris. Any anomalies must be documented/ photographed and coordinated with the results of the post launch shuttle/ pad area debris inspection.
Requirements:	OMRSD V09AJ0.095 - An engineering debris inspection team shall perform temperature measurements of RCC nose cap and RCC RH wing leading edge panels 9 and 17.
Documents:	OMI S0026, OMI S0027, OMI S0028

Report: Briefing to NASA Convoy Commander and generate PR's. Preliminary report to Level II on the day of landing followed by a more detailed update the next day.

8) Level II report

Objective: Compile and correlate data from all inspections and analyses. Results of the debris assessment, along with recommendations for corrective actions, are presented directly to Level II via SIR and PRCB. Paper copy of complete report follows in 3 to 4 weeks. (Ref NASA Technical Memorandum series).

3.0 SCRUB

3.1 PRE-TEST BRIEFING

The Ice/Frost/Debris Team briefing for launch activities was conducted on 23 July 1991 from 1200 to 1300 hours with the following key personnel present:

B. Bowen	NASA - KSC	ET Processing, Ice/Debris
K. Tenbusch	NASA - KSC	ET Processing, Ice/Debris
P. Rosado	NASA - KSC	Chief, ET Mechanical Systems
S. Higginbotham	NASA - KSC	STI, Ice/Debris Assessment
B. Davis	NASA - KSC	STI, Ice/Debris Assessment
G. Katnik	NASA - KSC	Lead, Ice/Debris/Photo Team
B. Speece	NASA - KSC	Lead, ET Thermal Protection
J. Rivera	NASA - KSC	Lead, ET Structures
M. Bassignani	NASA - KSC	ET Processing, Debris Assess
A. Oliu	NASA - KSC	ET Processing, Ice/Debris
A. Biamonte	NASA - KSC	ET Processing, Ice/Debris
J. Hoffman	LSOC - SPC	Supervisor, ET Mech Systems
M. Young	LSOC - SPC	ET Processing, Ice Assess
R. Seale	LSOC - SPC	ET Processing, Ice Assess
M. Jaime	LSOC - SPC	ET Processing, Ice Assess
W. Richards	LSOC - SPC	ET Processing, Ice Assess
M. Dean	LSOC - SPC	ET Processing, Ice Assess
Z. Byrns	NASA - JSC	Level II Integration
C. Gray	MMC - MAF	ET TPS & Materials Design
S. Copsey	MMC - MAF	ET TPS Testing/Certif
J. McClymonds	RI - DNY	Debris Assess, LVL II Integ
J. Stone	RI - DNY	Debris Assess, LVL II Integ
K. Mayer	RI - LSS	Vehicle Integration
S. Otto	MMC - LSS	ET Processing
J. Worden	USBI - LSS	SRB Processing
J. Cook	MTI - LSS	SRM Processing
R. Hillard	MTI - LSS	SRM Processing

These personnel participated in various team activities, assisted in the collection and evaluation of data, and contributed to reports contained in this document.

3.2 PRE-LAUNCH SSV/PAD DEBRIS INSPECTION

The pre-launch debris inspection of the pad and Shuttle vehicle was conducted on 23 July 1991 from 1300-1500 hours. The detailed walkdown of Launch Pad 39A and MLP-1 also included the primary flight elements OV-104 Atlantis (9th flight), ET-47 (LWT-40), and BI045. Documentary photographs were taken of facility anomalies, potential sources of vehicle damaging debris, and vehicle configuration changes.

There were no vehicle anomalies. The ET tumble valve cover was intact and properly configured.

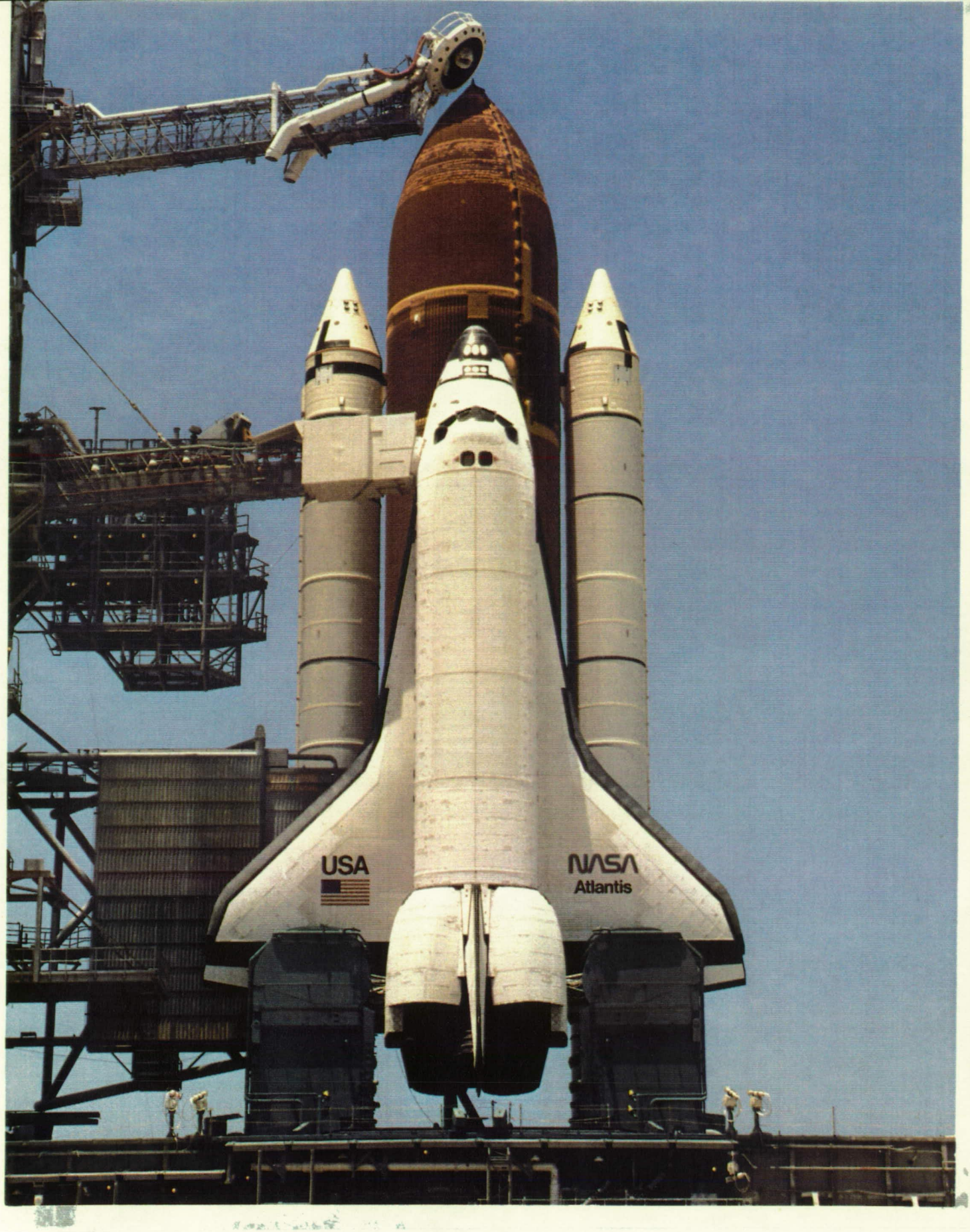
Due to the continued concern over potential hydrogen leakage from the ET/ORB LH2 umbilical interface area during cryoload/ launch, temporary hydrogen leak detectors LD54 and LD55 were installed at the LH2 ET/ORB umbilical until a permanent sensor could be designed and installed. The tygon tubes are intended to remain in place during cryogenic loading and be removed by the Ice Inspection Team during the T-3 hour hold.

An MLP deck bolt south of the hydrogen dispersal system pipe was loose. Another deck bolt east of the RH SRB under the sound suppression water pipe could be freely rotated by hand. A platform tether with a missing cotter pin was loose on the northwest corner of the LO2 TSM. Portable Purge Unit (PPU) electrical box covers at the northwest corner of the MLP were also loose.

Two pneumatic line caps for the MLP high-speed camera purge lines were found on the deck. Paper targets and tape still adhered to the MLP rainbirds and north stairwell. Protective foam and tape were attached to four firex nozzles on the south side of the SSME exhaust hole.

Cleanup of the MLP deck and pad surface was almost complete at the time of the inspection. Debris, such as deck scale, slag, safety wire, sand, and a white tie wrap, lay on the south holddown post haunches. A small piece of angle iron was visible on the HDP #6 haunch. K5NA trimmings were present on the HDP #1 and #5 DCS housings, holddown posts, and haunch areas.

The facility discrepancies were worked real-time or entered into OMI S0007, Appendix K, for resolution prior to vehicle tanking.



The STS-43 stack consisted of OV-104 (9th flight), ET-47 (LWT 40), and BI045 SRB's

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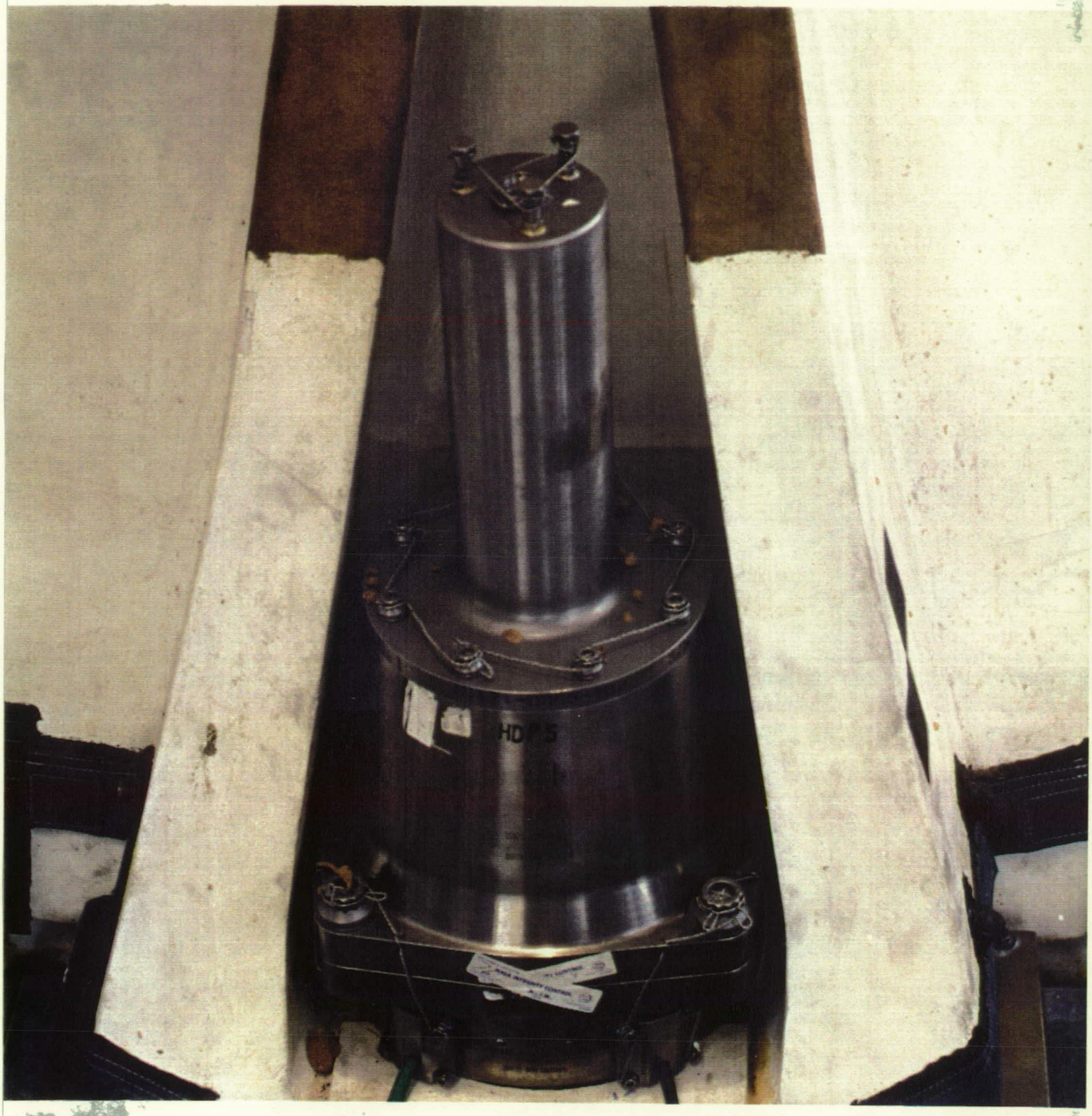

K5NA trimmings were present on the HDP #1 and #5 DCS housings, holddown posts, and haunch areas

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3.3 POST DRAIN INSPECTION

The STS-43 launch was scrubbed due to a failure in the SSME #3 controller Digital Computer Unit (DCU). The LH2 and LO2 tanks had been filled to 100 percent (stable replenish). A post-drain walkdown of the SSV and the MLP was performed at Pad-39A from 1030 to 1215 hours on 24 July 1991.

Most of the protuberance ice that had been visible on OTV during cryogenic loading had melted by the time the inspection was performed. There was no visible TPS damage, such as divots or cracks, on the ET LO2 tank, Intertank, or LH2 tank acreage.

The tumble valve cover was intact. There were no anomalies on the -Y side of the nosecone, fairing, louver, and footprint area. The +Y side of the nosecone was not accessible for inspection.

Both bipod jack pad closeouts were intact. There was no evidence of debonds or cracks.

Small amounts of ice were still present in the LO2 feedline support brackets. None of the brackets appeared to have damaged or loose foam. Some ice remained in all LO2 feedline bellows.

No cracks were visible in either thrust strut-to-longeron interfaces. A 1.5"x1" area in the +Y longeron BX-250 adjacent to the aft +Z depth-gage core closeout was protruding with 1/8-inch offset. PR ET-47-TS-0020 was taken with an MRB approval to use-as-is based on ice acceptance criteria in NSTS-08303.

Neither the LO2 nor LH2 ET/ORB umbilicals exhibited TPS anomalies or unusual ice/frost accumulations. Ice fingers, 3-4 inches in length, remained on the umbilical pyrotechnic canister purge vents. There was no ice or frost on the 17-inch flapper valve actuator access port closeout. Some ice remained in the LH2 feedline and recirculation line bellows.

Ice was still present in both left and right SRB cable tray to upper strut fairing interfaces. EB-7 and EB-8 fittings were still covered with ice.

No cause was apparent for the froth formations on the LH2 aft dome spray abort (sanded ring). There were no visible TPS anomalies on the LH2 aft dome apex and none of the SLA vents/ plug pull repairs were protruding. No TPS defects appeared on the manhole cover closeout rings (-Z cover at the -Y position and the +Z cover at the -Z,-Y position) where vapors had been observed.

All ice formations fell within the established data base and were acceptable per NSTS-08303.

No anomalies were visible on the Orbiter or SRB TPS.

The SRB sound suppression water troughs were properly configured and filled with water. There were no facility discrepancies. The tygon tube for LD55 was not visible above the LH2 umbilical and had moved slightly out of position.

The summary of Ice/Frost Team observations/anomalies consisted of 4 OTV recorded items:

Anomaly 001 documented vapors from the LH2 aft manhole closeout rings (-Y position on the -Z manhole; -Y-Z position on the +Z manhole). No discrepancies were detected during the post drain inspection.

Anomaly 002 recorded frost formations on the +Y side of the cable tray adjacent to the LO2 feedline support bracket. However, comparison of this condition to the pre-cryo load mapping tape showed this area was a repair, not a frost spot.

Anomaly 003 documented froth formations on the LH2 tank aft dome at the spray abort (sanded ring). No TPS defects were visible during the post drain inspection.

Anomaly 004 recorded two frost spots on the +Y longeron BX-250 near the aft +Z depth-gage core closeout. PR ET-47-TS-0020 was taken against a 1.5"x1" delamination along the foam knit line with 1/8-inch offset. The area was accepted by MRB approval for unrestricted use-as-is.

The tumble valve cover was intact. There were no anomalies on the nosecone, fairing, louver, and footprint areas.

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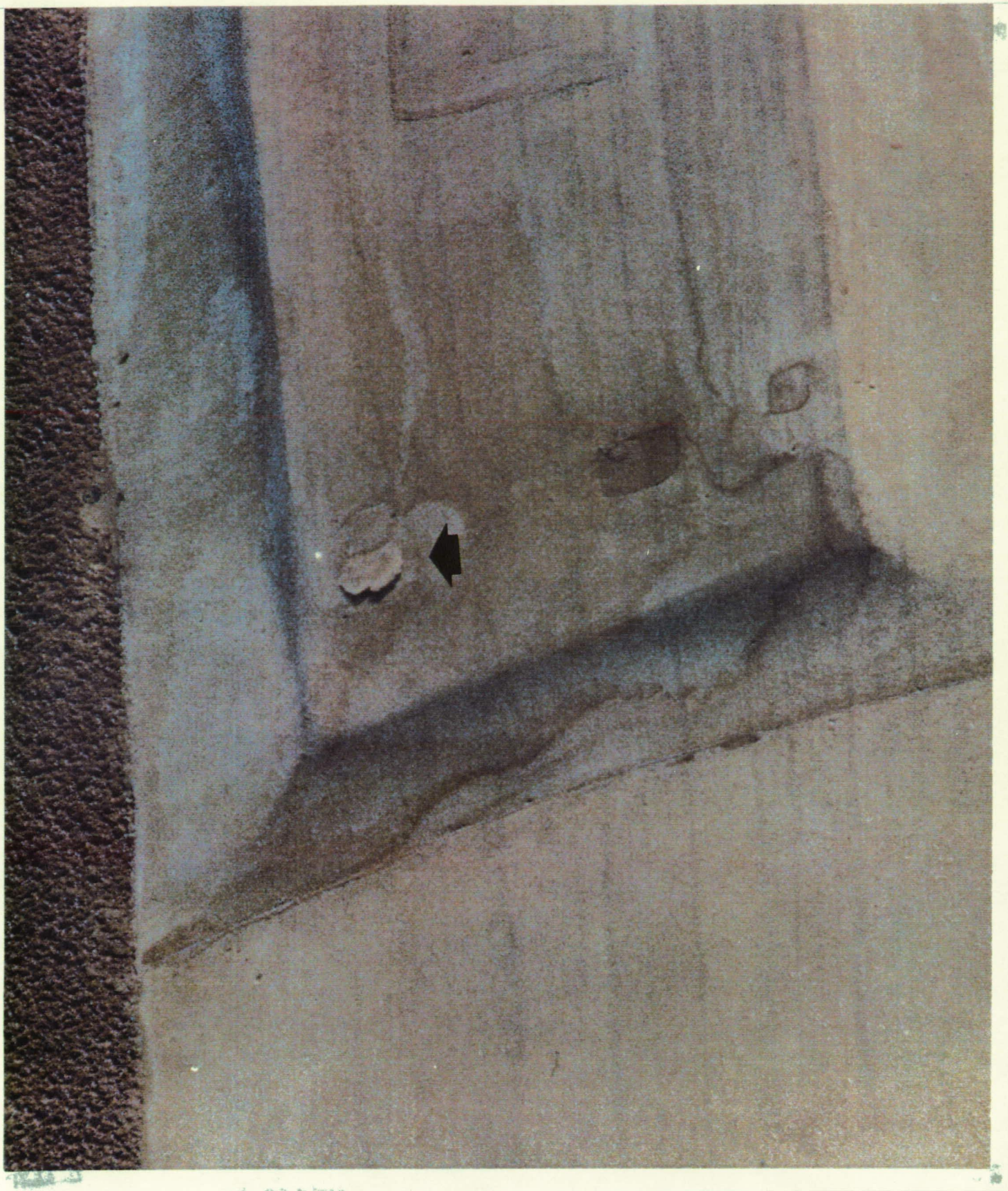

A 1.5"x1" area in the +Y longeron BX-250 adjacent to the aft +Z depth-gage core closeout protruded with 1/8-inch offset. An MRB approved the condition for flight based on acceptance criteria in NSTS-08303.

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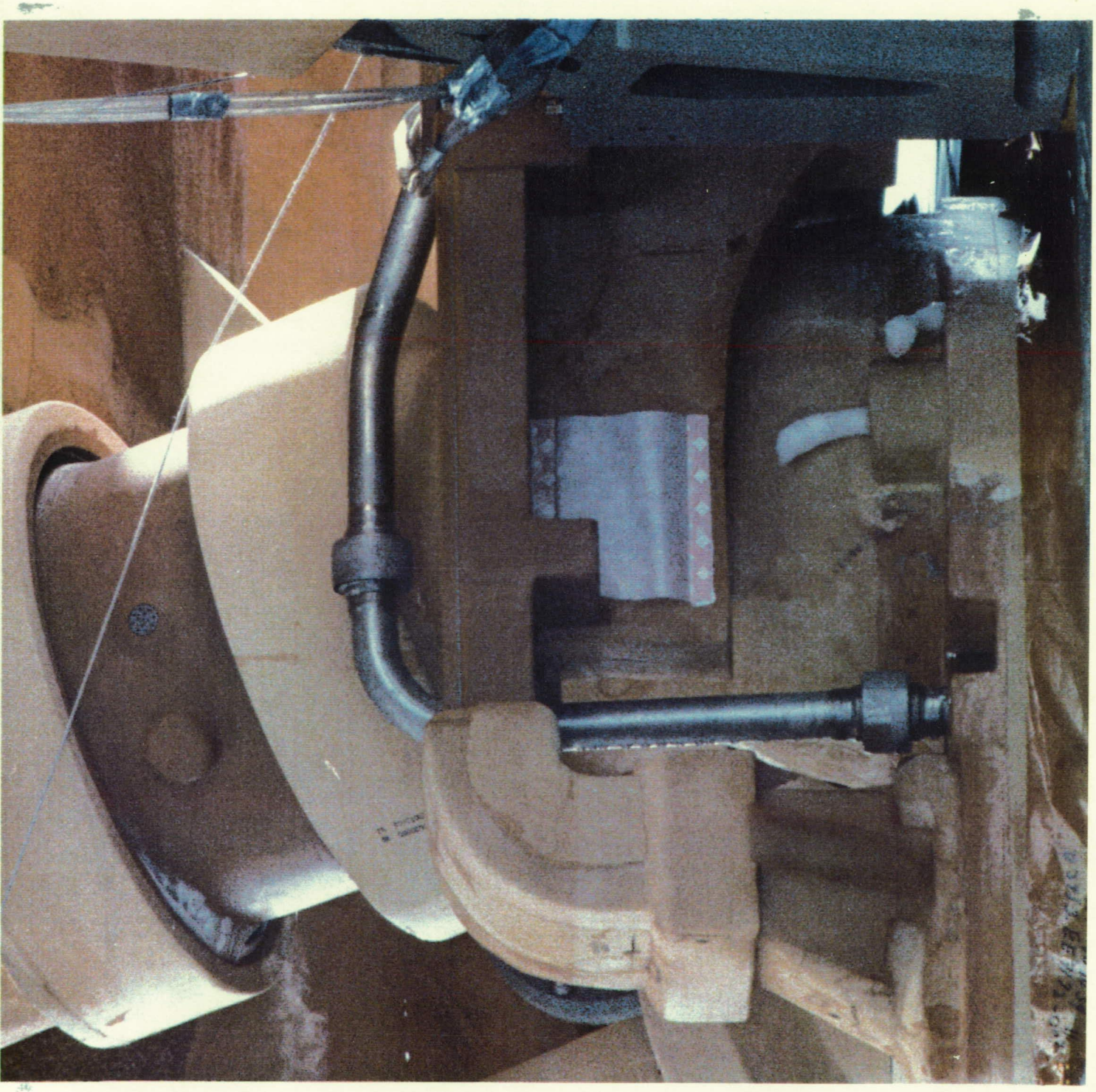

The LH2 ET/ORB umbilical exhibited no TPS anomalies or unusual ice/frost formations. Some ice remained in the LH2 feedline bellows

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The LH2 ET/ORB umbilical exhibited no TPS anomalies or unusual ice/frost formations. The ice finger on the aft pyro canister was typical. There was no ice or frost on the 17-inch flapper valve actuator access port closeout.

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4.0 SCRUB

4.1 PRE-LAUNCH SSV/PAD DEBRIS INSPECTION

A second pre-launch debris inspection of the pad and Shuttle vehicle was conducted on 31 July 1991 from 1300-1400 hours. The walkdown of Launch Pad 39A and MLP-1 also included the primary flight elements OV-104 Atlantis (9th flight), ET-47 (LWT-40), and BI045. Documentary photographs were taken of facility anomalies, potential sources of vehicle damaging debris, and vehicle configuration changes.

The tygon tubes for hydrogen leak detection sensors LD 54 and 55, which had been removed during the first launch attempt, were re-installed on the vehicle.

An OIS J-pipe cover on the west side of the SSME exhaust hole was loose. Protective foam secured with tape covered the four FIREX nozzles on the south corners of the SSME exhaust hole.

Small pieces of deck scale, paint flakes, and foam trimmings were present in the haunch areas and under the raised deck. The deck was vacuumed/washed down prior to cryoload.

The facility discrepancies were worked real-time or entered into OMI S0007, Appendix K, for resolution prior to vehicle tanking.

Pre-cryo load view of the STS-43 stack

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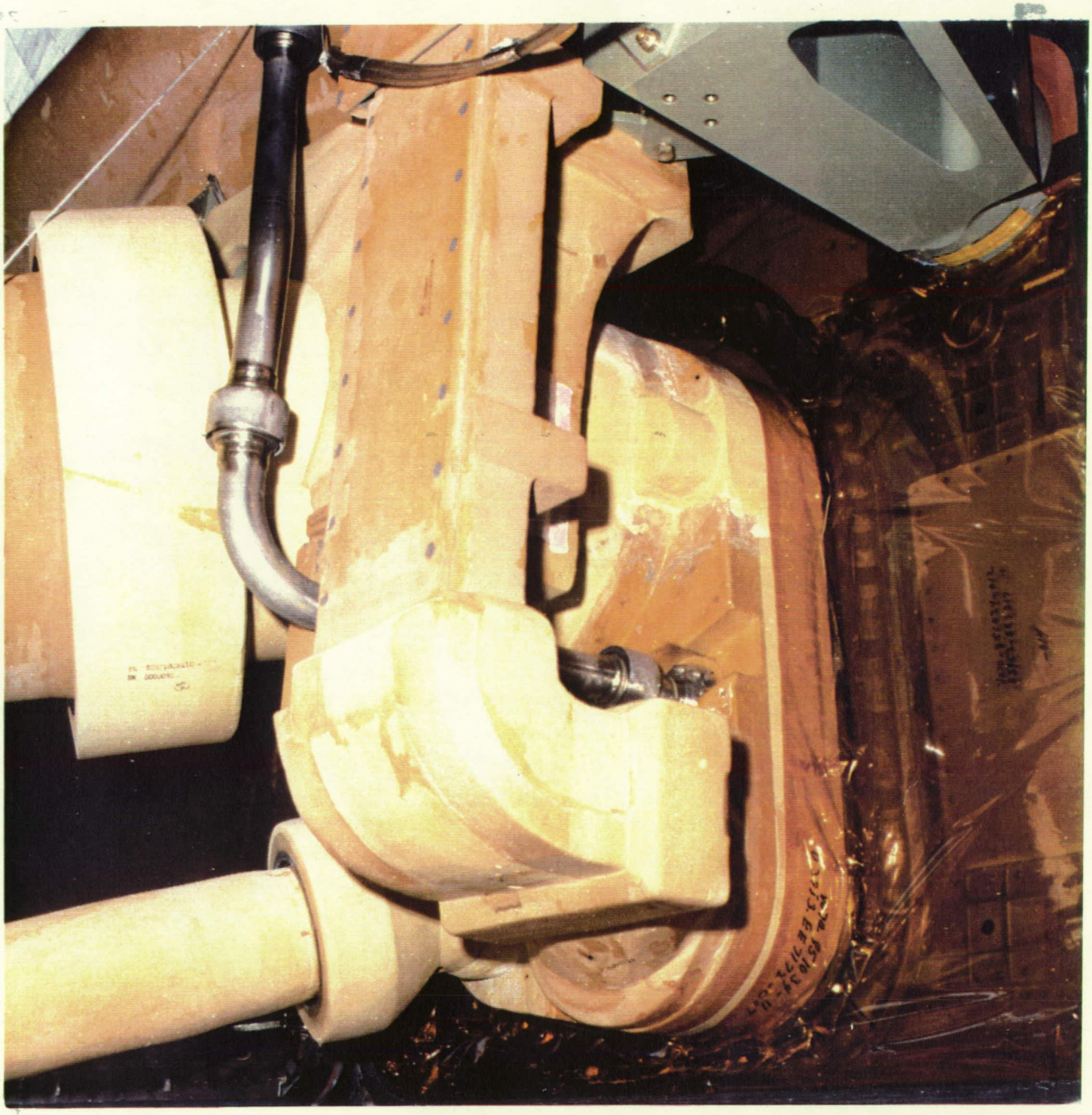

Overall view of the LH2 ET/ORB umbilical

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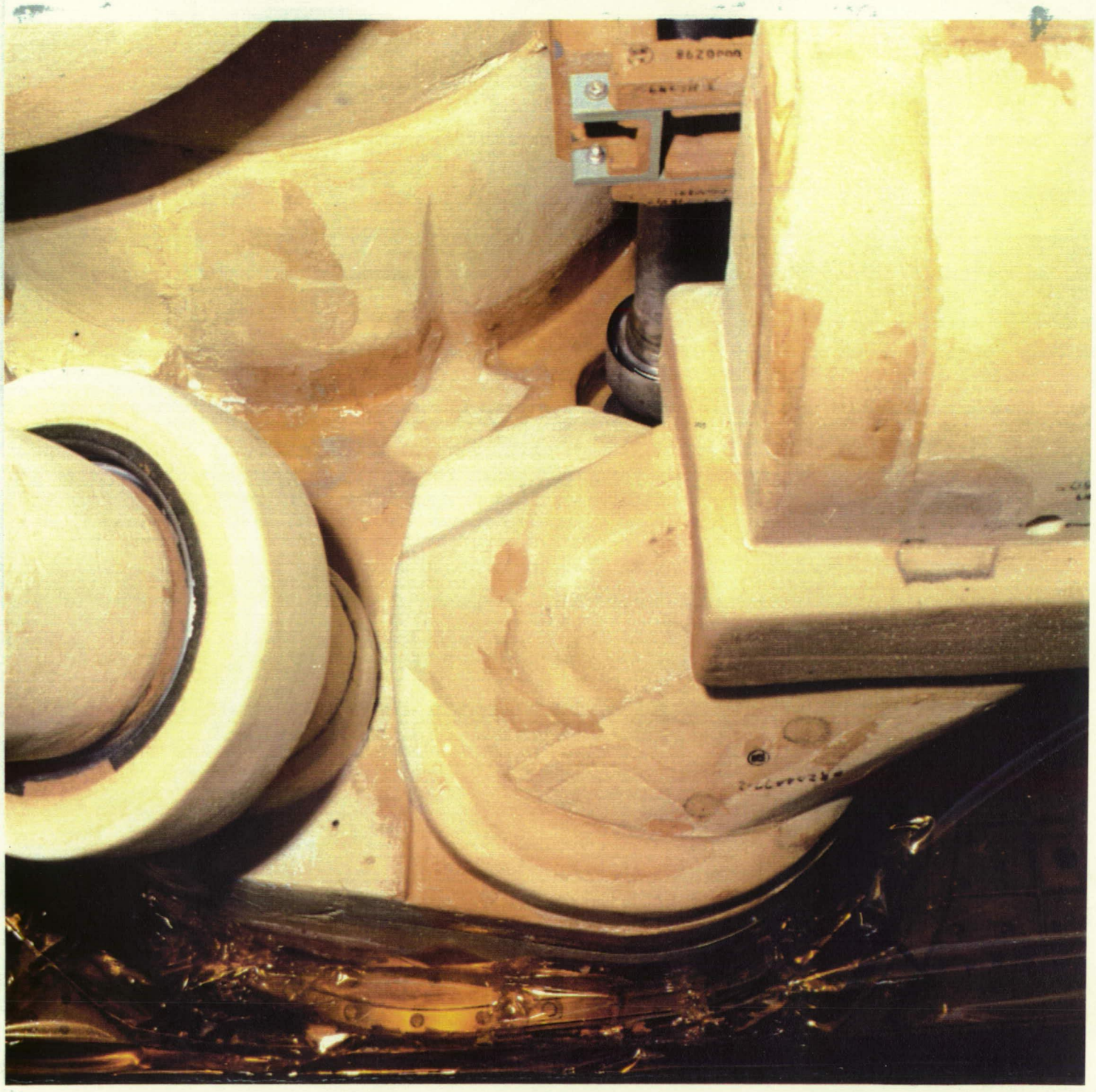

Overall view of the LH2 ET/ORB umbilical, cable tray, LH2 feedline interface, and recirculation line interface

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4.2 ICE/FROST INSPECTION

The Ice/Frost Inspection of the cryoloaded vehicle was performed on 1 August 1991 from 0520 to 0740 hours during the two hour built-in-hold at T-3 hours in the countdown. There were no Launch Commit Criteria, OMRS, or NSTS-08303 violations. There were no conditions outside of the established data base. One facility IPR was taken against a LOX leak in the LO2 TSM. Ambient weather conditions at the time of the inspection were:

Temperature:	78.3 F
Relative Humidity:	91.3 %
Wind Speed:	10.8 Knots
Wind Direction:	159 Degrees

A portable infrared radiometer was utilized to obtain surface temperature measurements for an overall thermal assessment of the vehicle, as shown in Figure 1 and 2.

4.3 ORBITER

No Orbiter tile anomalies were observed. All RCS paper covers were wet from recent rain, but were intact. There was no evidence of a leak or a liquid level line on any of the RCS paper covers. The water spray boiler plugs were intact. The average Orbiter surface temperature was 74-78 degrees F. The average surface temperatures of the SSME engine mounted heat shields were measured at 73 degrees F for SSME #1, 72 degrees F for SSME #2, and 74 degrees F for SSME #3. The coldest area on the engine mounted heat shields was less than 32 degrees F where frost was present at the interface. All of the SSME heat shields were wet with some condensate. Light frost coated the SSME #1 heat shield-to-nozzle interface at the 8-10, 11-12, and 3 o'clock position. Light frost also coated the SSME #2 heat shield-to-nozzle interface at the 3-9 o'clock position. One of the SSME #1 drain lines was covered by frost. No GOX vapors originated from inside the SSME nozzles. Some condensate was present on base heat shield tiles between SSME #2 and #3 and outboard of SSME #2.

4.4 SOLID ROCKET BOOSTERS

No SRB anomalies or loose ablator/cork were observed. The K5NA closeouts of the aft booster stiffener ring splice plates were intact. The Cyclops infrared radiometer recorded RH and LH SRB case surface temperatures between 76 and 79 degrees F. The Mikron IR radiometer gave measurements between 72 and 77 degrees F. In comparison, the GEI gave readings between 78 and 82 degrees F. The predicted Propellant Mean Bulk Temperature (PMBT) supplied by MTI was 83 degrees F, which was within the required range of 44-86 degrees F.

FIGURE 1 **SSV INFRARED SCANNER SURFACE TEMPERATURE SUMMARY DATA**

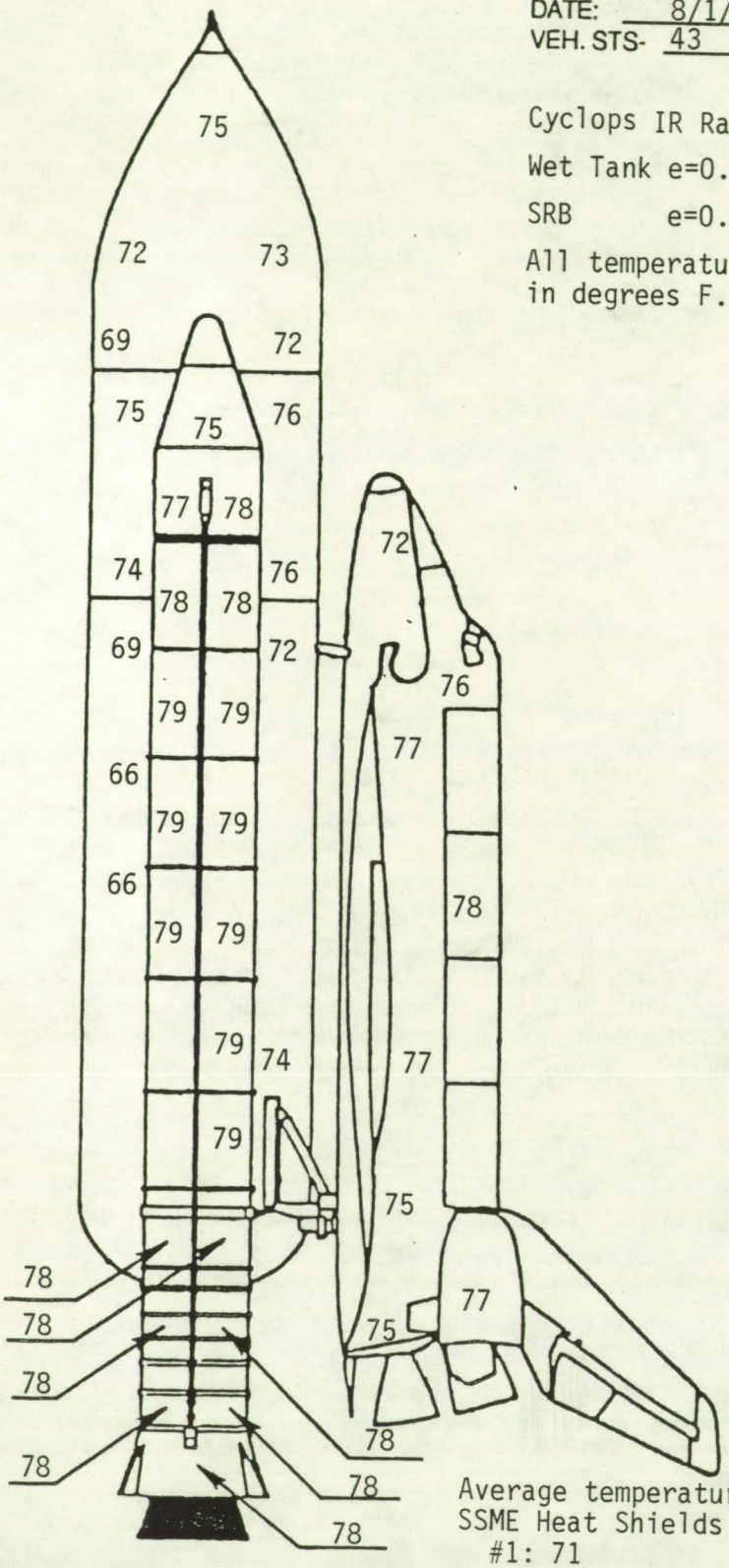
TIME: 0530 - 0730
DATE: 8/1/91
VEH. STS- 43

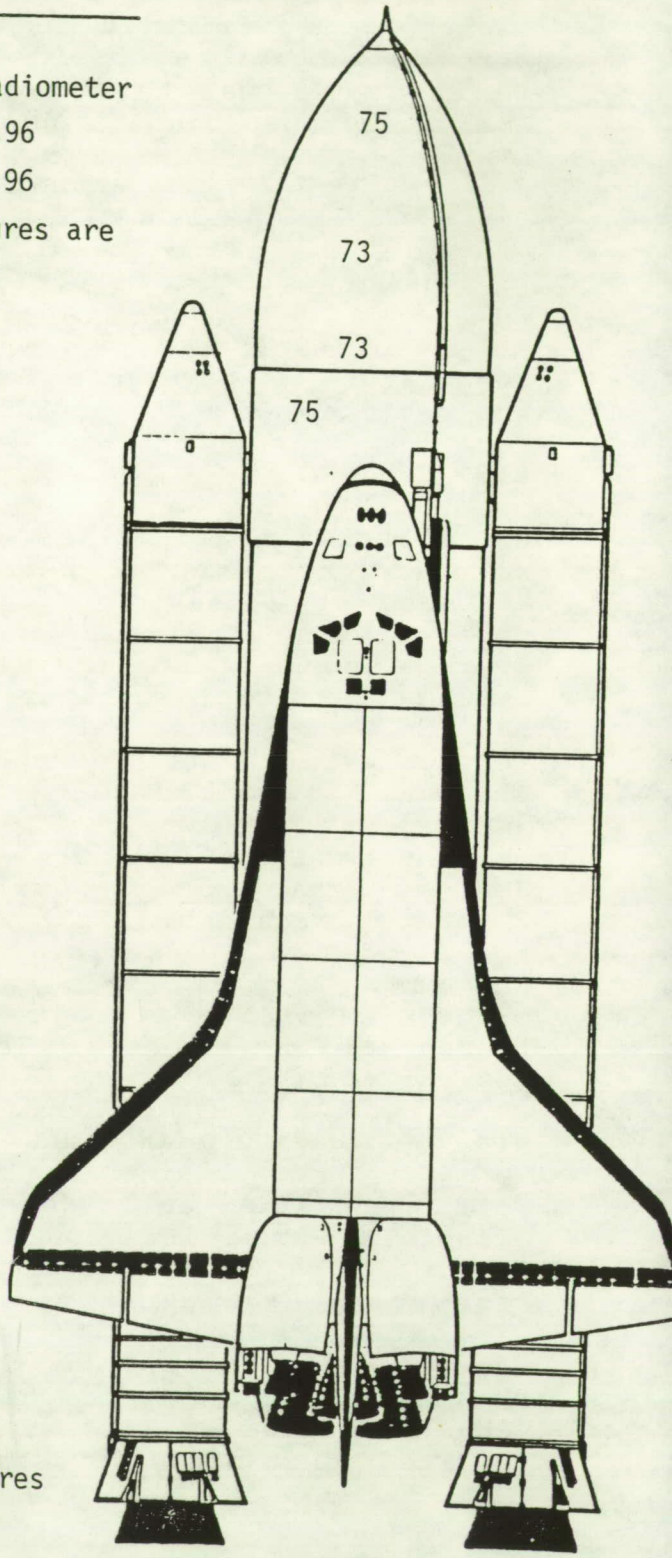
Cyclops IR Radiometer

Wet Tank e=0.96

SRB e=0.96

All temperatures are in degrees F.





Average temperatures
SSME Heat Shields
#1: 71
#2: 74
#3: 74

FIGURE 2. **SSV INFRARED SCANNER SURFACE TEMPERATURE SUMMARY DATA**

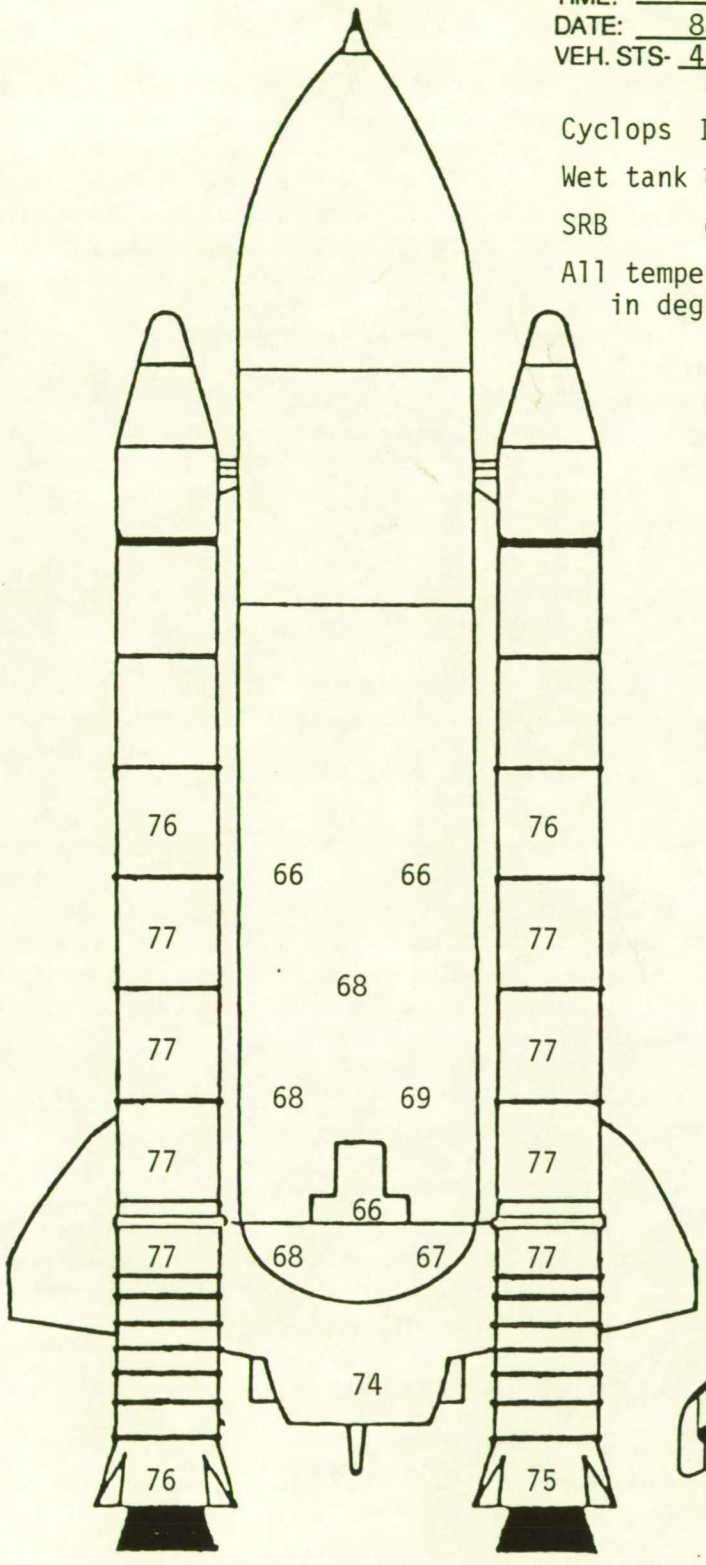
TIME: 0530-0730
DATE: 8/1/91
VEH. STS- 43

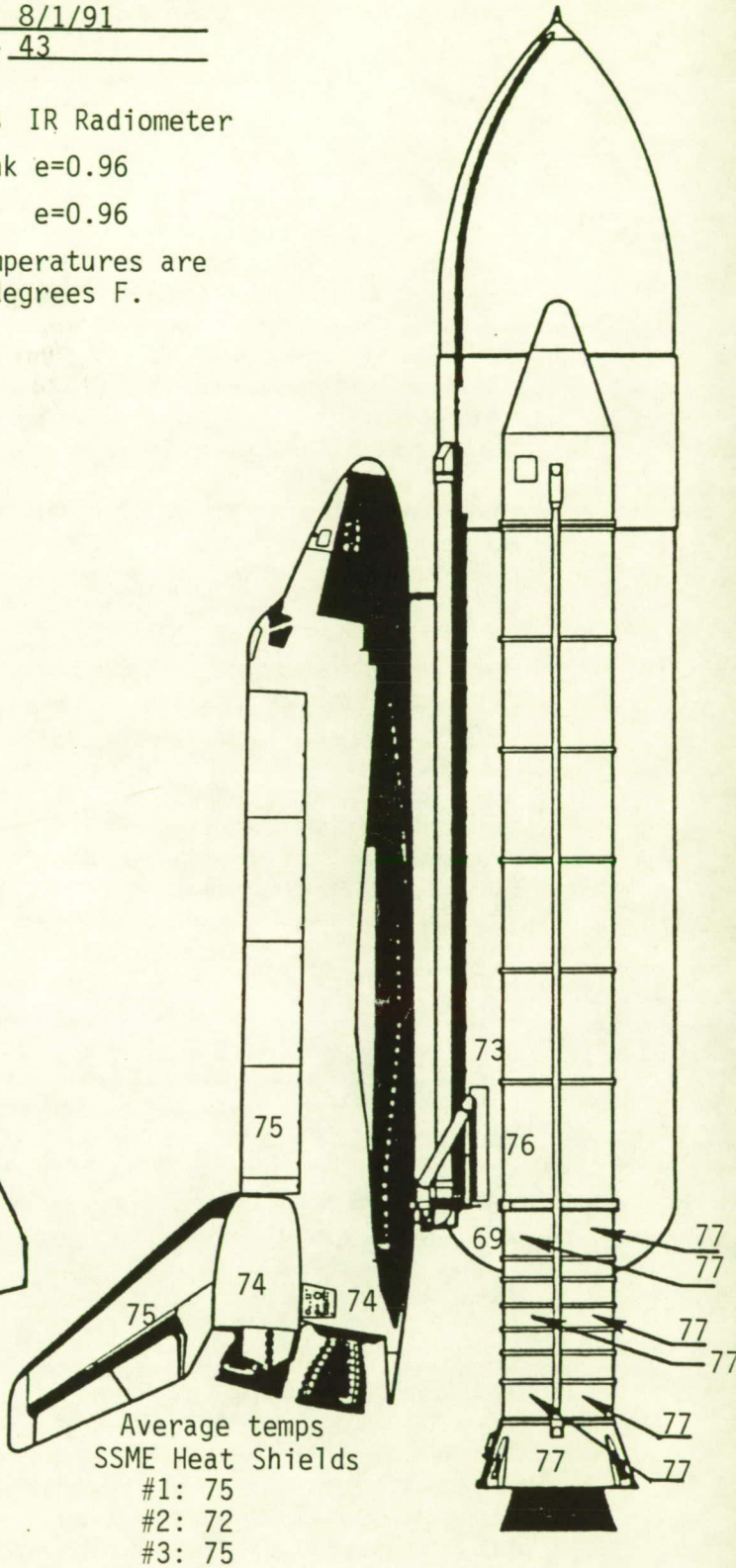
Cyclops IR Radiometer

Wet tank e=0.96

SRB e=0.96

All temperatures are in degrees F.





Average temps
SSME Heat Shields
#1: 75
#2: 72
#3: 75

EGG/V-343C

4.5 EXTERNAL TANK

The ice/frost prediction computer program 'SURFICE' was run from 0245 to 1230 hours and the results tabulated in Figures 3 and 4. The program predicted condensate with no ice accumulation on all TPS acreage surfaces.

Very light condensate, but no ice or frost, was present on the LO2 tank barrel TPS acreage. There was no ice/frost or condensate on the LO2 tank ogive. There were no TPS anomalies. The tumble valve cover was intact. There were no anomalies on the pressurization line and support ramps. The stationary STI unit on the RSS roof measured a surface temperature of 74 degrees F on the ogive and 72 degrees F on the barrel section. SURFICE predicted 71 degrees F on the ogive and 68 degrees F on the barrel section. The Cyclops IR radiometer measured 75 and 73 degrees F, respectively.

The intertank TPS acreage was wet with light run-off condensate. There were no TPS anomalies. Three small frost spots appeared in the stringer valleys at the LH2 tank flange near the -Z axis. No unusual ice formations or cryogenic drips were present on the ET umbilical carrier plate. The RSS STI IR scanner measured an average surface temperature of 76 degrees F compared to a Cyclops IR radiometer measurement of 75 degrees Fahrenheit.

The LH2 tank and aft dome TPS acreage were covered with a moderate amount of condensate. There was no ice/frost on the acreage. The average surface temperatures as measured by the RSS STI IR scanner were 71 degrees F on the upper LH2 tank and 72 degrees F on the lower LH2 tank compared to a Cyclops IR radiometer measurements of 68 and 68 degrees F, respectively. SURFICE predicted 67 degrees F on the upper LH2 tank and 66 degrees F on the lower LH2 tank.

There were no anomalies on the bipods, jack pads, PAL ramp, cable tray/press line ice/frost ramps, thrust struts, manhole covers, or aft dome apex with the exception of a small ice/frost spot on the -Z manhole cover. The frost spot later melted. Some ice/frost was present in the ET/SRB cable tray-to-upper strut fairing expansion joints. Ice/frost covered the lower EB fittings outboard to the strut pin hole with condensate on the rest of the fitting. The struts were dry.

Typical amounts of ice/frost were present in all LO2 feedline bellows and support brackets.

There were no anomalies on the LO2 ET/ORB umbilical. The purge barrier (baggie) was configured properly and was holding positive purge pressure. Small scattered accumulations of ice/frost were present of the outboard and aft areas of the baggie. There was no ice/frost accumulation on the acreage areas of the umbilical. Ice/frost fingers 3-6 inches in length had formed on

STS- 43	TEST S0007 SCRUB - RTLS WEATHER																					DATE: 1 August 1991		T-0 TIME: DATE:		NASA KSC Ice/Frost/Debris Team
ORBITER 104	ET 47	SRB BI-045	MLP 1	PAD A	LO2 CHILLDOWN TIME: 02:16 FAST FILL TIME: 02:54 SLOW FILL TIME: 02:40 REPLENISH TIME: 05:02											LH2 CHILLDOWN TIME: FAST FILL TIME: 02:35 SLOW FILL TIME: 02:12 REPLENISH TIME: 04:48											
TIME (EDT)	CONDITIONS					LO2 TANK STA 370 TO 540					LO2 TANK STA 550 TO 852					LH2 TANK STA 1130 TO 1380					LH2 TANK STA 1380 TO 2058				
	TEMP F	REL. HUM. %	DEW PT F	WIND VEL KNTS	WIND DIR DEG	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR
245	79.20	90.6	76.37	11	170	II	6.49	72.83	0.0033	-0.3211	II	6.49	69.84	0.0056	-0.2868	II	4.62	66.82	0.0058	-0.2030	II	4.18	66.00	0.0057	-0.1844
245	79.20	90.6	76.37	11	170	II	6.49	72.83	0.0033	-0.3211	II	6.49	69.84	0.0056	-0.2868	II	4.62	66.82	0.0058	-0.2030	II	4.18	66.00	0.0057	-0.1844
300	78.80	91.4	76.22	9	171	II	5.31	71.87	0.0033	-0.2689	II	5.31	68.31	0.0055	-0.2356	II	3.78	64.84	0.0056	-0.1656	II	3.42	63.92	0.0055	-0.1502
315	78.80	92.2	76.47	11	173	II	6.49	72.78	0.0034	-0.3206	II	6.49	69.78	0.0058	-0.2863	II	4.62	66.74	0.0059	-0.2025	II	4.18	65.92	0.0058	-0.1839
330	79.20	93.8	77.36	12	160	II	7.08	73.87	0.0036	-0.3552	II	7.08	71.11	0.0060	-0.3202	II	5.04	68.28	0.0062	-0.2273	II	4.56	67.50	0.0061	-0.2066
345	78.20	94.4	76.55	11	150	II	6.49	72.63	0.0036	-0.3191	II	6.49	69.62	0.0060	-0.2849	II	3.52	64.18	0.0057	-0.1545	II	15.29	73.15	0.0067	-0.6323
400	78.20	95.0	76.73	13	146	II	7.67	73.31	0.0037	-0.3701	II	7.67	70.71	0.0061	-0.3350	II	4.16	65.83	0.0060	-0.1828	II	18.07	73.82	0.0068	-0.7456
415	78.60	94.6	77.01	11	154	II	6.49	73.12	0.0037	-0.3246	II	6.49	70.13	0.0060	-0.2901	II	3.52	64.72	0.0058	-0.1578	II	15.29	73.62	0.0068	-0.6430
430	78.20	94.6	76.61	12	157	II	7.08	72.97	0.0037	-0.3443	II	7.08	70.18	0.0060	-0.3096	II	3.84	65.03	0.0058	-0.1685	II	16.68	73.48	0.0068	-0.6883
445	77.80	94.0	76.03	9	160	II	5.31	71.37	0.0035	-0.2644	II	5.31	67.78	0.0057	-0.2312	II	3.78	64.26	0.0057	-0.1619	II	3.42	63.32	0.0056	-0.1467
500	77.60	93.2	75.58	11	160	II	6.49	71.71	0.0035	-0.3088	II	6.49	68.66	0.0058	-0.2748	II	4.62	65.56	0.0059	-0.1935	II	4.18	64.72	0.0058	-0.1755
515	78.20	93.0	76.12	11	159	II	6.49	72.31	0.0035	-0.3155	II	6.49	69.29	0.0058	-0.2813	II	4.62	66.22	0.0059	-0.1985	II	4.18	65.39	0.0058	-0.1802
530	78.40	90.8	75.64	13	164	II	7.67	72.56	0.0033	-0.3601	II	7.67	69.92	0.0056	-0.3253	II	5.46	67.20	0.0059	-0.2305	II	4.94	66.45	0.0058	-0.2093
545	78.00	90.6	75.18	9	173	II	5.31	70.81	0.0032	-0.2590	II	5.31	67.20	0.0054	-0.2260	II	3.78	63.68	0.0055	-0.1581	II	3.42	62.75	0.0053	-0.1433
600	78.40	89.9	75.35	12	165	II	7.08	72.09	0.0032	-0.3336	II	7.08	69.27	0.0055	-0.2992	II	5.04	66.39	0.0057	-0.2116	II	4.56	65.60	0.0056	-0.1921
615	78.40	90.4	75.51	13	160	II	7.67	72.46	0.0032	-0.3588	II	7.67	69.83	0.0056	-0.3241	II	5.46	67.11	0.0059	-0.2296	II	4.94	66.36	0.0058	-0.2085
630	78.80	91.0	76.10	10	148	II	5.90	72.16	0.0033	-0.2928	II	5.90	68.90	0.0056	-0.2591	II	3.20	63.19	0.0054	-0.1402	II	13.90	72.64	0.0062	-0.5733
645	78.00	92.4	75.74	9	149	II	5.31	71.22	0.0034	-0.2629	II	5.31	67.63	0.0056	-0.2298	II	2.88	61.46	0.0052	-0.1231	II	12.51	71.72	0.0064	-0.5090
700	78.00	93.4	76.04	9	153	II	5.31	71.45	0.0035	-0.2651	II	5.31	67.87	0.0057	-0.2319	II	2.88	61.71	0.0053	-0.1243	II	12.51	71.96	0.0065	-0.5135
715	77.80	92.4	75.54	10	158	II	5.90	71.40	0.0034	-0.2851	II	5.90	68.10	0.0056	-0.2515	II	4.20	64.81	0.0057	-0.1767	II	3.80	63.92	0.0056	-0.1602
730	78.40	90.8	75.64	12	156	II	7.08	72.31	0.0033	-0.3361	II	7.08	69.49	0.0056	-0.3017	II	3.84	64.36	0.0055	-0.1640	II	16.68	72.78	0.0060	-0.6709
745	79.20	89.4	75.99	11	166	II	6.49	72.55	0.0032	-0.3179	II	6.49	69.54	0.0055	-0.2837	II	4.62	66.52	0.0057	-0.2007	II	4.18	65.71	0.0056	-0.1823
800	79.60	87.4	75.74	14	161	II	8.26	73.22	0.0029	-0.3898	II	8.26	70.79	0.0053	-0.3546	II	5.88	68.26	0.0057	-0.2523	II	5.32	67.56	0.0056	-0.2293
815	80.00	86.8	75.94	14	168	II	8.26	73.50	0.0028	-0.3936	II	8.26	71.07	0.0053	-0.3582	II	5.88	68.56	0.0056	-0.2551	II	5.32	67.87	0.0056	-0.2319
830	81.40	87.0	77.39	12	163	II	7.08	74.58	0.0029	-0.3636	II	7.08	71.88	0.0054	-0.3285	II	5.04	69.14	0.0057	-0.2343	II	4.56	68.40	0.0056	-0.2133
845	82.00	86.4	77.79	12	165	II	7.08	75.07	0.0029	-0.3697	II	7.08	72.39	0.0053	-0.3344	II	5.04	69.68	0.0057	-0.2389	II	4.56	68.94	0.0056	-0.2175
900	82.00	85.6	77.52	13	166	II	7.67	75.10	0.0028	-0.3930	II	7.67	72.59	0.0052	-0.3573	II	5.46	70.03	0.0056	-0.2555	II	4.94	69.33	0.0056	-0.2326
915	82.40	85.0	77.72	13	175	II	7.67	75.37	0.0027	-0.3965	II	7.67	72.87	0.0052	-0.3608	II	5.46	70.33	0.0056	-0.2582	II	4.94	69.63	0.0055	-0.2352

FIGURE 3. 'SURFICE' Computer Predictions

STS- 43	TEST S0007 SCRUB - RTLS WEATHER																						DATE: 1 August 1991				T-0 TIME: DATE:		NASA KSC Ice/Frost/Debris Team
ORBITER 104	ET 47	SRB BI-045	MLP 1	PAD A	LO2 CHILLDOWN TIME: 02:16 SLOW FILL TIME: 02:40						FAST FILL TIME: 02:54 REPLENISH TIME: 05:02						LH2 CHILLDOWN TIME: SLOW FILL TIME: 02:12						FAST FILL TIME: 02:35 REPLENISH TIME: 04:48							
TIME	CONDITIONS					LO2 TANK STA 370 TO 540					LO2 TANK STA 550 TO 852					LH2 TANK STA 1130 TO 1380					LH2 TANK STA 1380 TO 2058							
(EDT)	TEMP F	REL. HUM. %	DEW PT F	WIND VEL KNTS	WIND DIR DEG	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR				
930	83.00	84.0	77.98	15	174	II	8.85	76.12	0.0025	-0.4538	II	8.85	73.92	0.0050	-0.4172	II	6.30	71.66	0.0056	-0.2994	II	5.70	71.03	0.0055	-0.2728				
945	83.20	82.6	77.69	14	174	II	8.26	75.79	0.0023	-0.4254	II	8.26	73.46	0.0049	-0.3892	II	5.88	71.08	0.0054	-0.2792	II	5.32	70.43	0.0054	-0.2544				
1000	84.00	82.0	78.27	15	168	II	8.85	76.64	0.0022	-0.4616	II	8.85	74.46	0.0048	-0.4248	II	6.30	72.24	0.0054	-0.3054	II	5.70	71.62	0.0054	-0.2784				
1015	84.60	82.0	78.87	13	165	II	7.67	76.90	0.0023	-0.4172	II	7.67	74.46	0.0049	-0.3810	II	5.46	72.02	0.0054	-0.2739	II	4.94	71.35	0.0054	-0.2498				
1030	85.00	80.4	78.70	15	163	II	8.85	77.24	0.0020	-0.4709	II	8.85	75.09	0.0046	-0.4339	II	6.30	72.91	0.0053	-0.3125	II	5.70	72.31	0.0053	-0.2850				
1045	85.80	78.6	78.84	14	165	II	8.26	77.42	0.0018	-0.4488	II	8.26	75.15	0.0044	-0.4121	II	5.88	72.88	0.0051	-0.2971	II	5.32	72.26	0.0051	-0.2711				
1100	86.80	77.4	79.38	14	166	II	8.26	78.12	0.0017	-0.4592	II	8.26	75.87	0.0043	-0.4222	II	5.88	73.65	0.0050	-0.3049	II	5.32	73.04	0.0050	-0.2783				
1115	86.60	75.8	78.58	14	161	II	8.26	77.47	0.0014	-0.4492	II	8.26	75.20	0.0041	-0.4125	II	5.88	72.97	0.0048	-0.2977	II	5.32	72.35	0.0048	-0.2717				
1130	87.60	73.0	78.49	13	159	II	7.67	77.52	0.0012	-0.4249	II	7.67	75.12	0.0038	-0.3886	II	5.46	72.79	0.0045	-0.2807	II	4.94	72.16	0.0046	-0.2564				
1145	88.00	70.8	78.00	13	161	II	7.67	77.28	0.0008	-0.4213	II	7.67	74.88	0.0034	-0.3852	II	5.46	72.57	0.0043	-0.2784	II	4.94	71.93	0.0043	-0.2543				
1200	88.00	69.2	77.35	14	164	II	8.26	76.98	0.0005	-0.4412	II	8.26	74.71	0.0031	-0.4049	II	5.88	72.52	0.0040	-0.2926	II	5.32	71.91	0.0041	-0.2672				
1215	88.80	68.4	77.80	16	160	II	9.44	77.82	0.0000	-0.5033	II	9.44	75.81	0.0027	-0.4659	II	6.72	73.86	0.0038	-0.3373	II	6.08	73.31	0.0039	-0.3080				
1230	88.60	66.20	76.67	15	171	II	8.85	77.10	0.0000	-0.4625	II	6.42	64.18	0.0024	-0.4260	II	4.36	61.19	0.0035	-0.3081	II	6.28	62.44	0.0037	-0.2813				
AVG.	81.28	86.27	76.89	12.2	SSE		7.238	74.14																					

Period of Ice Team Inspection

FIGURE 4. 'SURFICE' Computer Predictions

the separation bolt pyrotechnic canister purge vents. Normal venting of nitrogen purge gas had occurred during tanking, stable replenish, and launch.

Ice/frost had formed in the LH2 recirculation line bellows and on both burst disks. The LH2 feedline bellows were wet with condensate. The forward and outboard sides of the LH2 ET/ORB umbilical were covered by typical ice/frost formations. Ice/frost accumulation on the inboard and aft areas of the baggie was light. Ice/frost fingers 2-3 inches in length had formed on the pyro canister and plate gap purge vents. A small amount of ice/frost had formed along the bondline of the aft pyro canister closeout (aft side), forward outboard pyro canister closeout (aft side), and recirculation line to umbilical closeout (aft side). These ice/frost formations were acceptable per NSTS-08303. Normal venting of helium purge gas had occurred during tanking, stable replenish, and launch. There were no unusual vapors emanating from the umbilicals nor any evidence of cryogenic drips. No ice or frost was present on the cable tray vent hole. The 17-inch flapper valve actuator access port foam plug was properly closed out with no ice/frost on the bondline. Torn butcher paper on the vertical strut was acceptable for launch and documented on an anomaly sheet.

The ET/ORB hydrogen detection sensor tygon tubing was in proper position prior to removal. The tubing was successfully removed from the vehicle with no flight hardware contact or TPS damage.

The summary of Ice/Frost Team observations/anomalies consisted of 5 OTV recorded items:

Anomaly 001 (documentation only) noted three frost spots in the -Z stringer valleys near the LH2 tank-to-intertank flange. Frost spots in these locations were acceptable per NSTS-08303.

Anomaly 002 recorded torn butcher paper for the hydrogen detection system on the -Z vertical strut. The paper was still able to serve the intended purpose of fire detection and was acceptable to the Debris Team.

Anomaly 003 (documentation only) noted ice/frost formations in the LO2 feedline bellows and brackets. These formations were acceptable per NSTS-08303.

Anomaly 004 (documentation only) recorded ice/frost formations at the LO2 and LH2 ET/ORB umbilicals in the areas of the purge barriers, separation bolt purge vents, and the LH2 umbilical intercavity purge vents. These formations were acceptable per NSTS-08303.

Anomaly 005 (documentation only) noted ice/frost accumulation in the LH2 feedline and recirculation line bellows. The accumulations were acceptable per NSTS-08303.

4.6 FACILITY

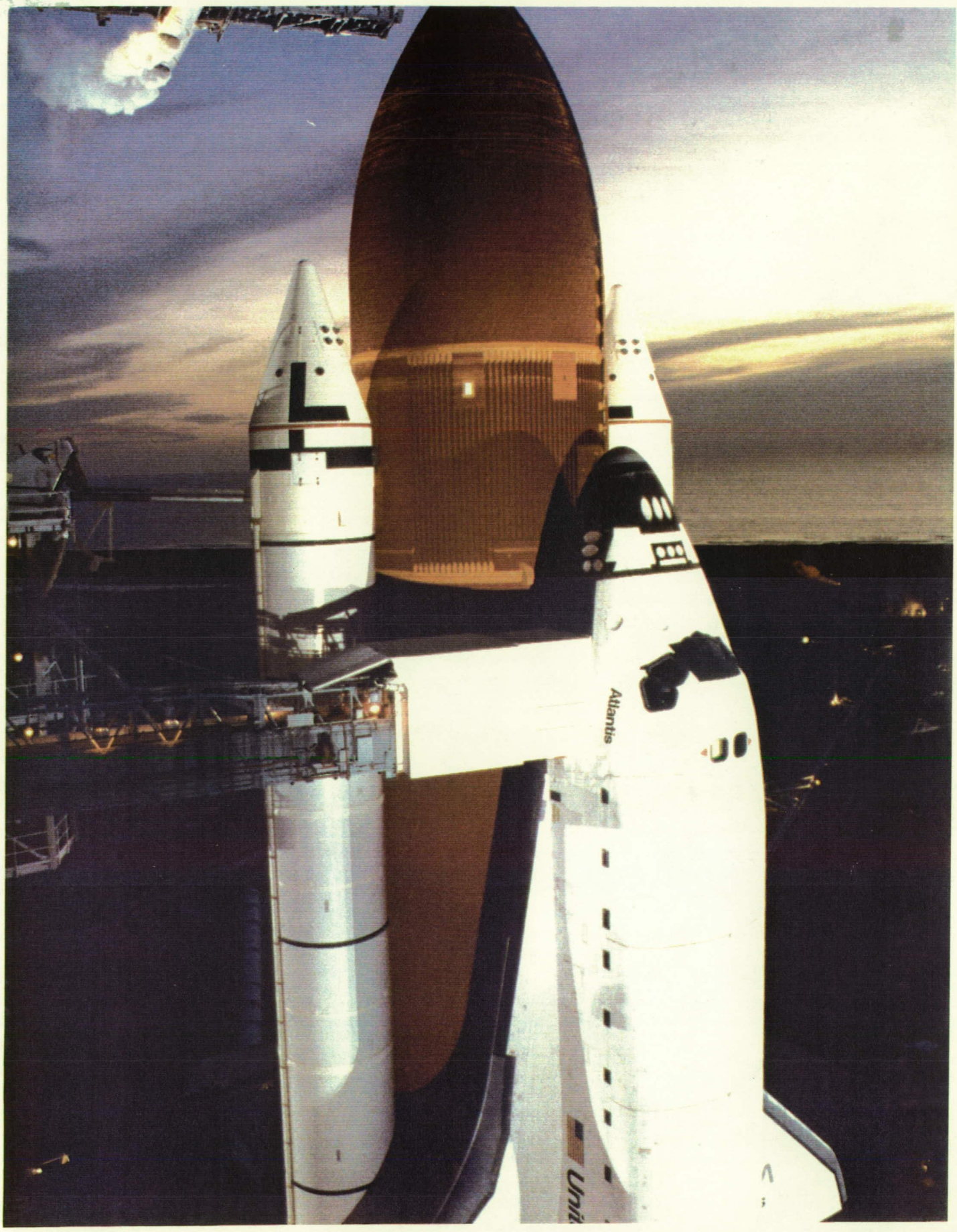
No new debris concerns had been identified during the ice/frost inspection of the vehicle.

All SRB sound suppression water troughs were filled and properly configured for launch.

No leaks were observed on either the LO2 or LH2 Orbiter T-0 umbilicals, though typical accumulations of ice/frost were present on the cryogenic lines. Excessive GOX vapors emanated from the open LO2 TSM door and a Launch Accessories IPR was taken against a suspected liquid oxygen leak inside the TSM. The vapors had not been present at the start of the Ice Team inspection on the MLP zero level but were visible when the Team returned to the MLP deck 90 minutes later. Condensate was present on the TSM walls from MLP deck level to half the height of the TSM. Infrared scanners measured 67 degrees F on the south wall of the TSM, 68 degrees on the east wall, and 68 degrees on the door compared to an average of 75 degrees F on the LH2 TSM. Engineering determined the suspected LOX leak would not be a constraint to launch.

During the topping phase of hydrogen tanking, leak detectors 23 and 25 showed a rapid rise to 20,000 ppm hydrogen in the GUCP cavity purge. The leakage settled into an oscillatory pattern of 5000 ppm for a period of 7 minutes. Review of correlated ET purge data showed the hydrogen readings to be synchronous with the ET intertank (normal) purge heater cycles and the venturi (normal) differential pressure, which may suggest some unknown pressure/thermal phenomena caused the leak by distorting the cavity/QD. No hydrogen leakage was detected during the first launch attempt on 24 July 1991. Externally, there was no apparent leakage anywhere on the GH2 vent line or GUCP. The modification to the GH2 vent line prevented ice from forming, but some ice/frost, which was expected, had accumulated on the GUCP legs and on the uninsulated parts of the umbilical carrier plate.

Visual and infrared observations of the GOX seals confirmed no leakage. No ET nosecone/footprint damage was visible after the GOX vent hood was retracted. There were no icicles on the GOX vent ducts.



There were no TPS anomalies or ice/frost accumulations on the External Tank acreage

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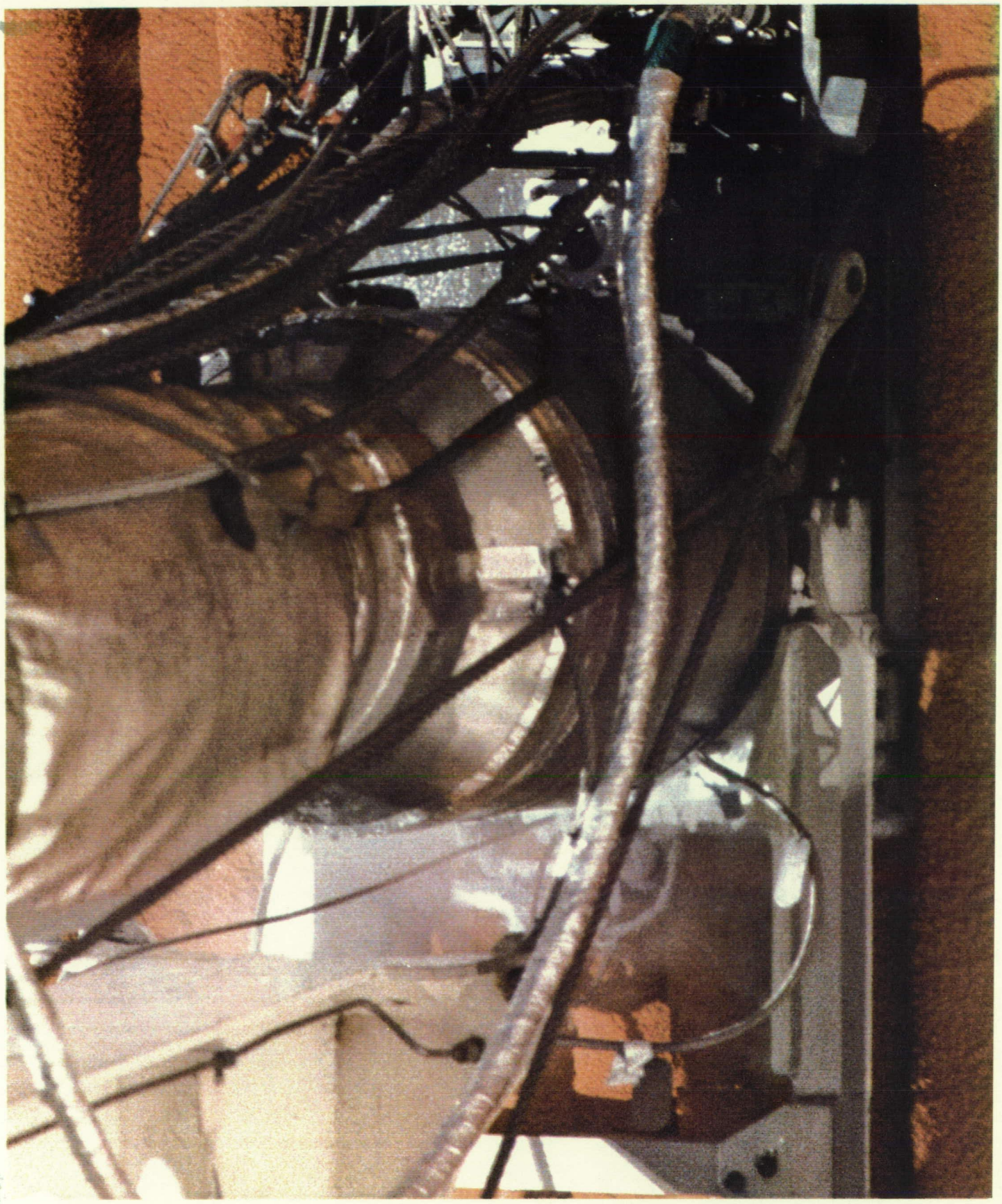

Although leak detectors 23 and 25 showed a hydrogen leak of 5000 ppm in the GUCP cavity purge, there were no unusual vapors or ice/frost formations externally. Ice/frost accumulations on the GUCP legs and trimmed TPS areas were typical.

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Ice/frost accumulations in the LO2 feedline support brackets were typical

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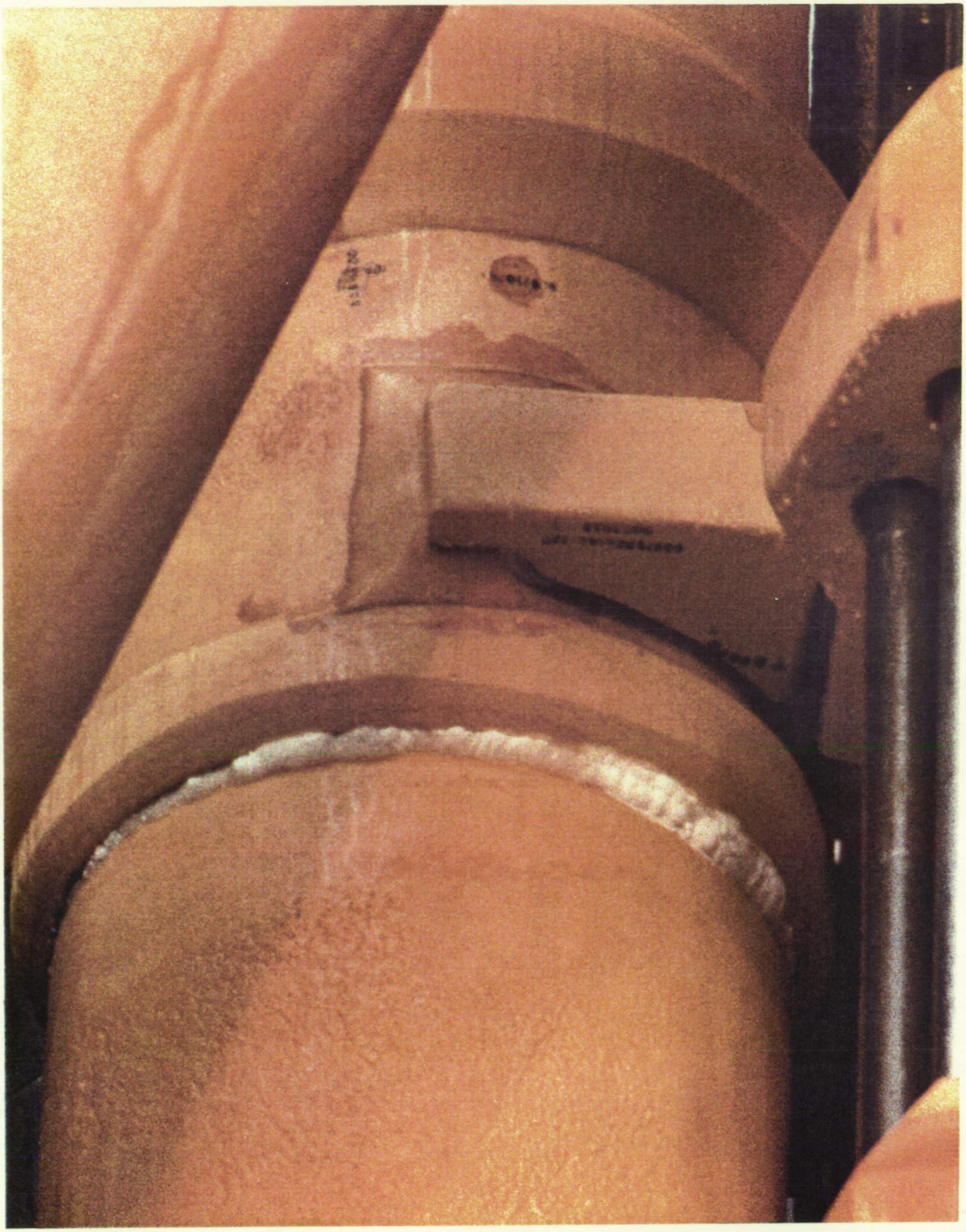

Ice/frost formations in the LO2 feedline bellows were typical

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A 1.5"x1" area in the +Y longeron BX-250 adjacent to the aft +Z depth-gage core closeout, though protruding with an 1/8-inch offset, formed no ice/frost during cryo load. An MRB approved the condition for flight based on acceptance criteria in NSTS-08303.

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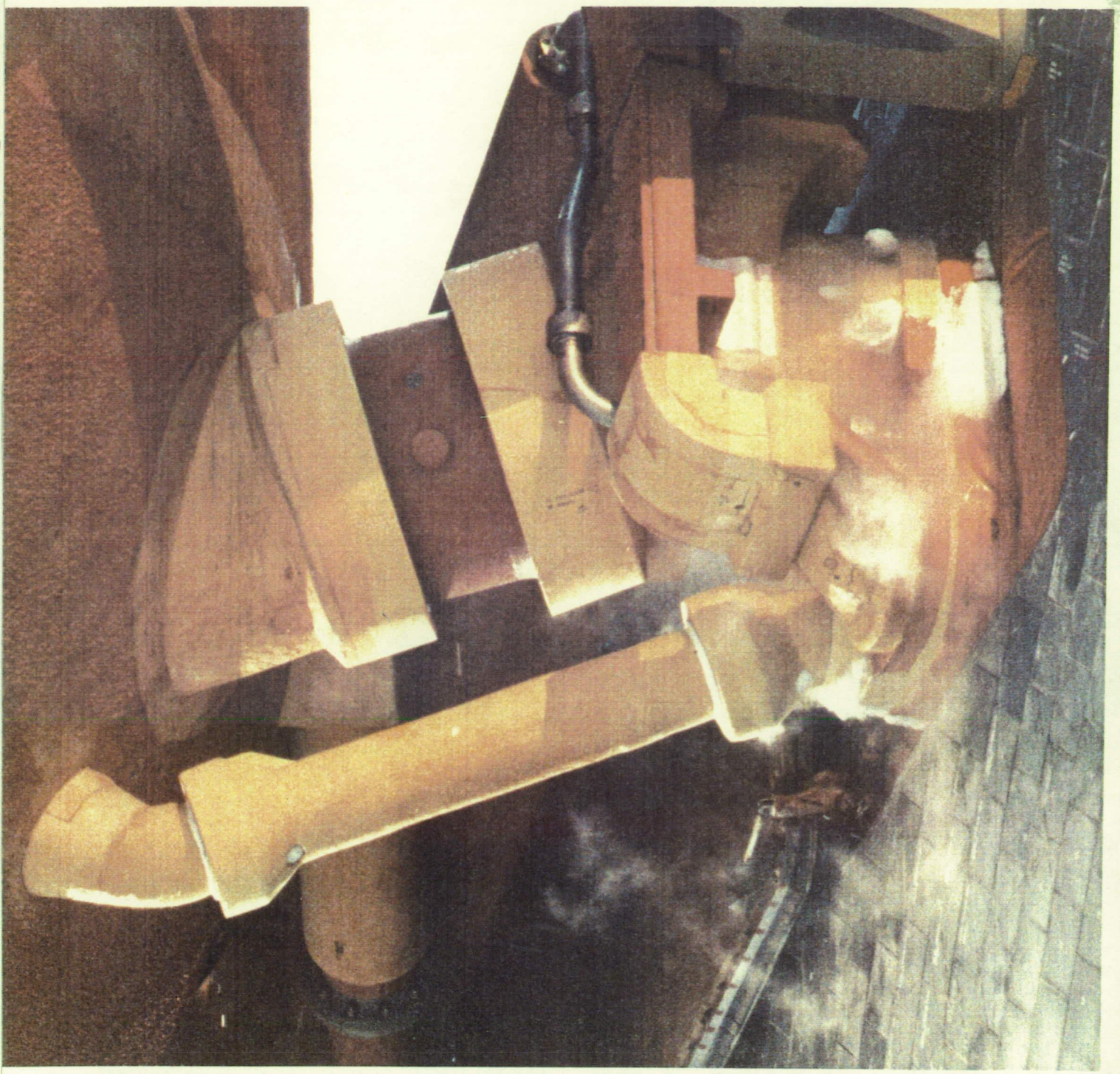

Overall view of the LH2 ET/ORB umbilical. Ice/frost accumulations on the umbilical outboard side and on the purge vents were typical. There were no unusual vapors emanating from the umbilical nor any evidence of cryogenic drips. Ice/frost in the recirculation line bellows and burst disks was typical.

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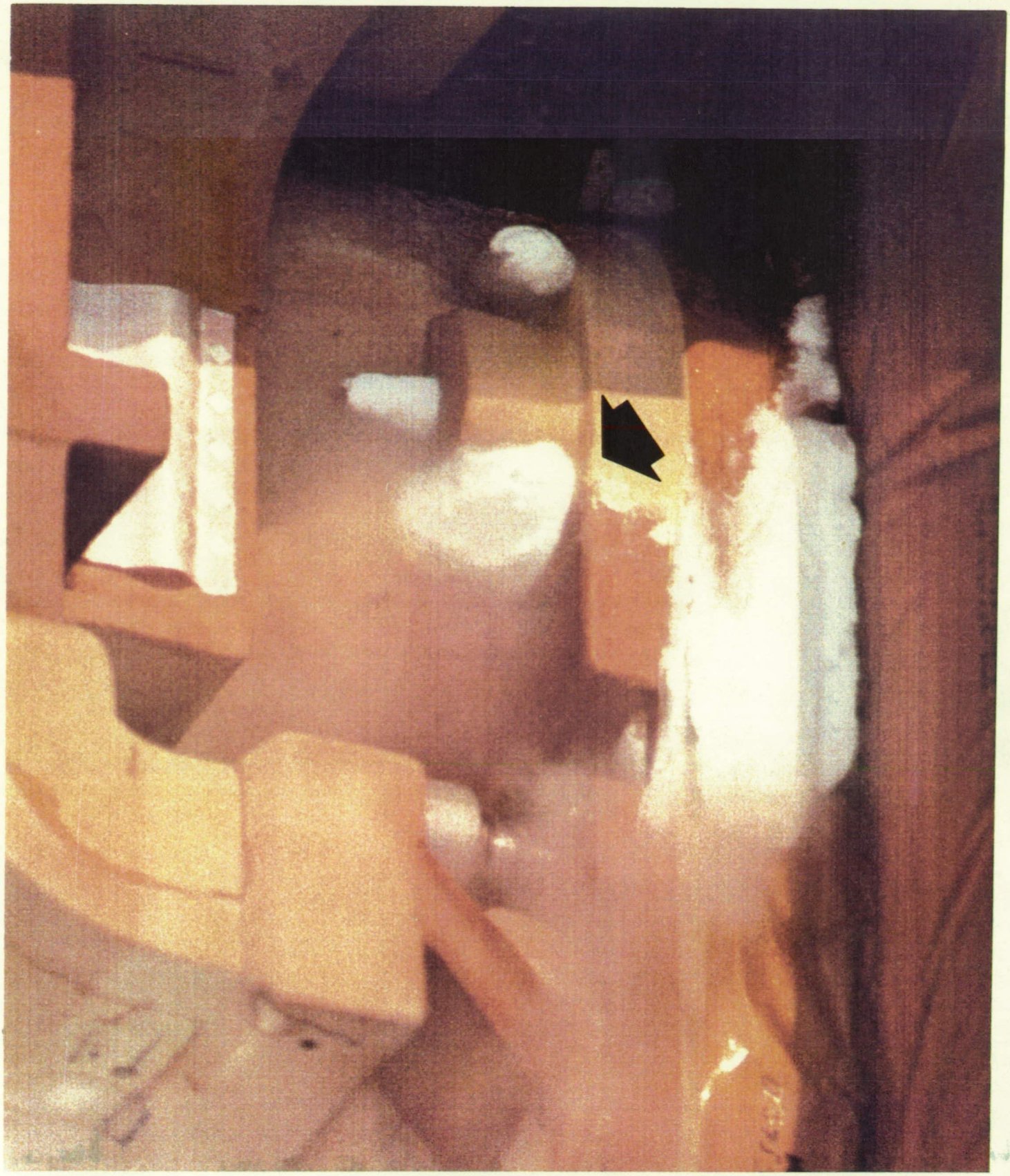

Ice/frost accumulations on the LH2 ET/ORB umbilical outboard side and top sides, plate gap purge vent, and forward outboard pyrotechnic canister purge vent were typical. A small amount of ice/frost had formed along the bondline of the pyro canister closeout (aft side) - an acceptable condition per NSTS-08303.

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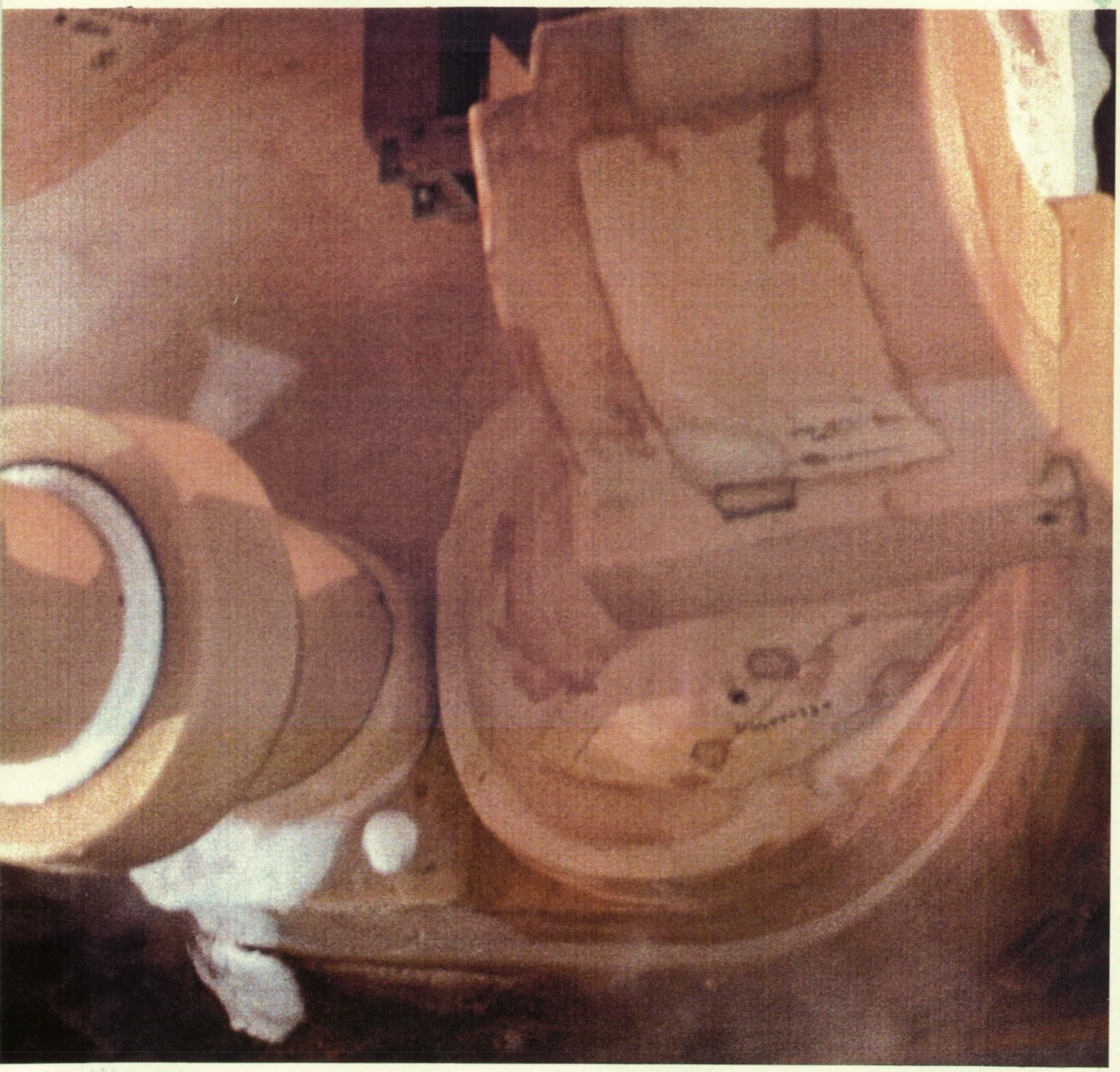

Ice/frost accumulations on the LH2 ET/ORB umbilical outboard side and aft sides, plate gap purge vent, and aft pyrotechnic canister purge vent were typical. A small amount of ice/frost had formed along the bondline of the pyro canister closeout (aft side) and recirculation line to umbilical interface. Both conditions were acceptable per NSTS-08303.

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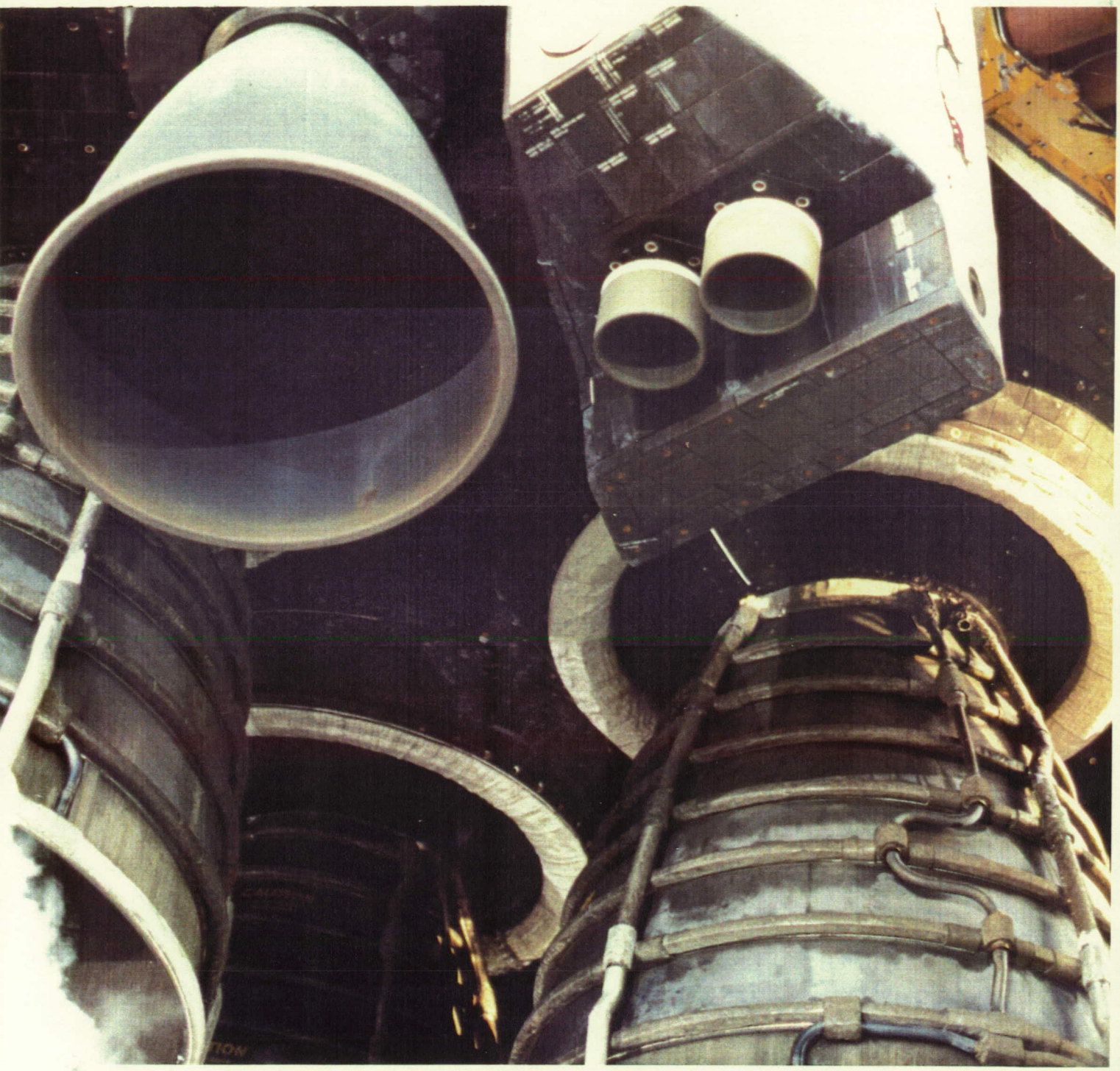

Overall view of SSME cluster and RH OMS nozzle

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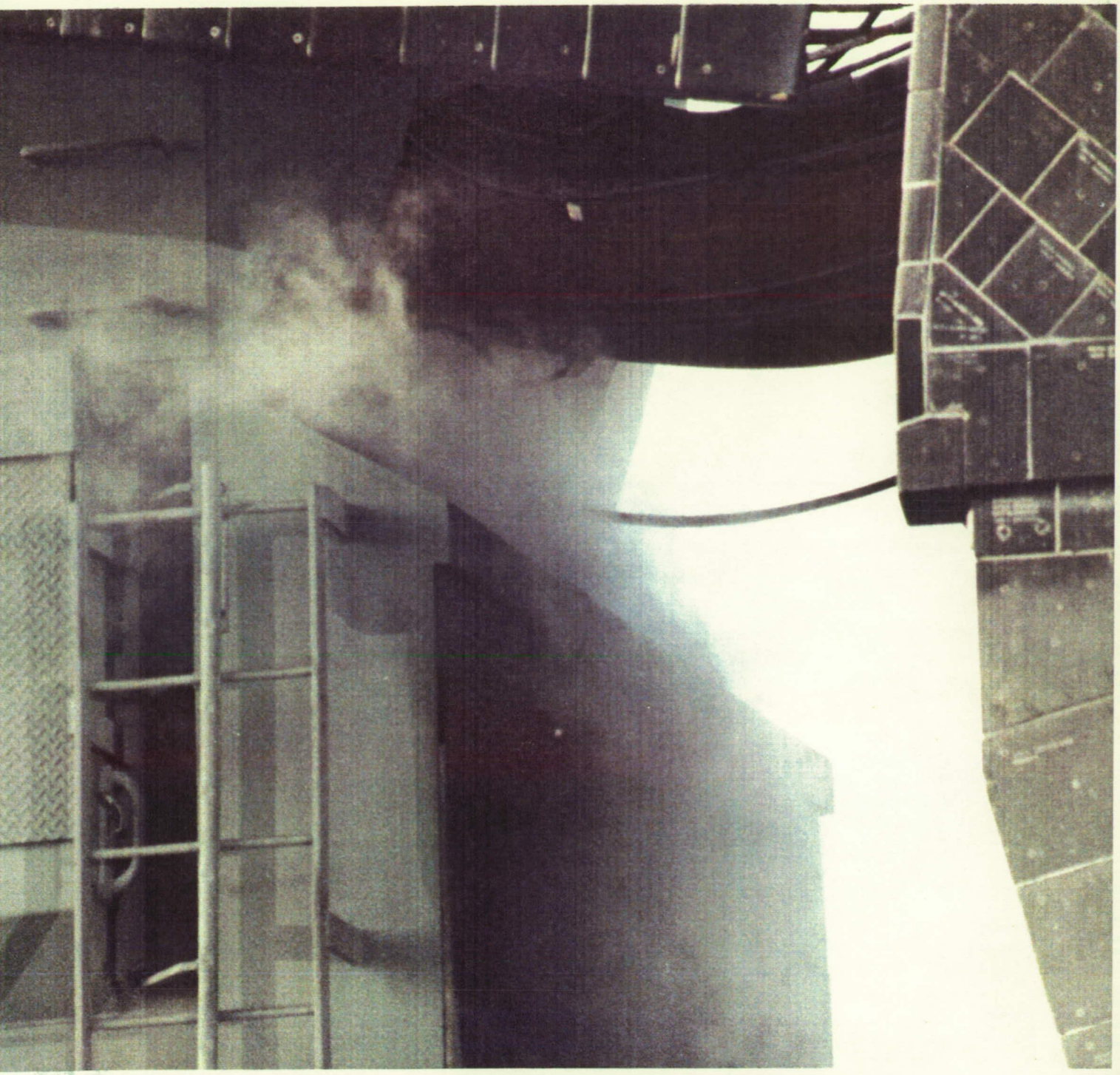

Excessive gaseous oxygen vapors emanated from the open door of the LO2 TSM and a facility IPR was taken against a suspected liquid oxygen leak inside the TSM

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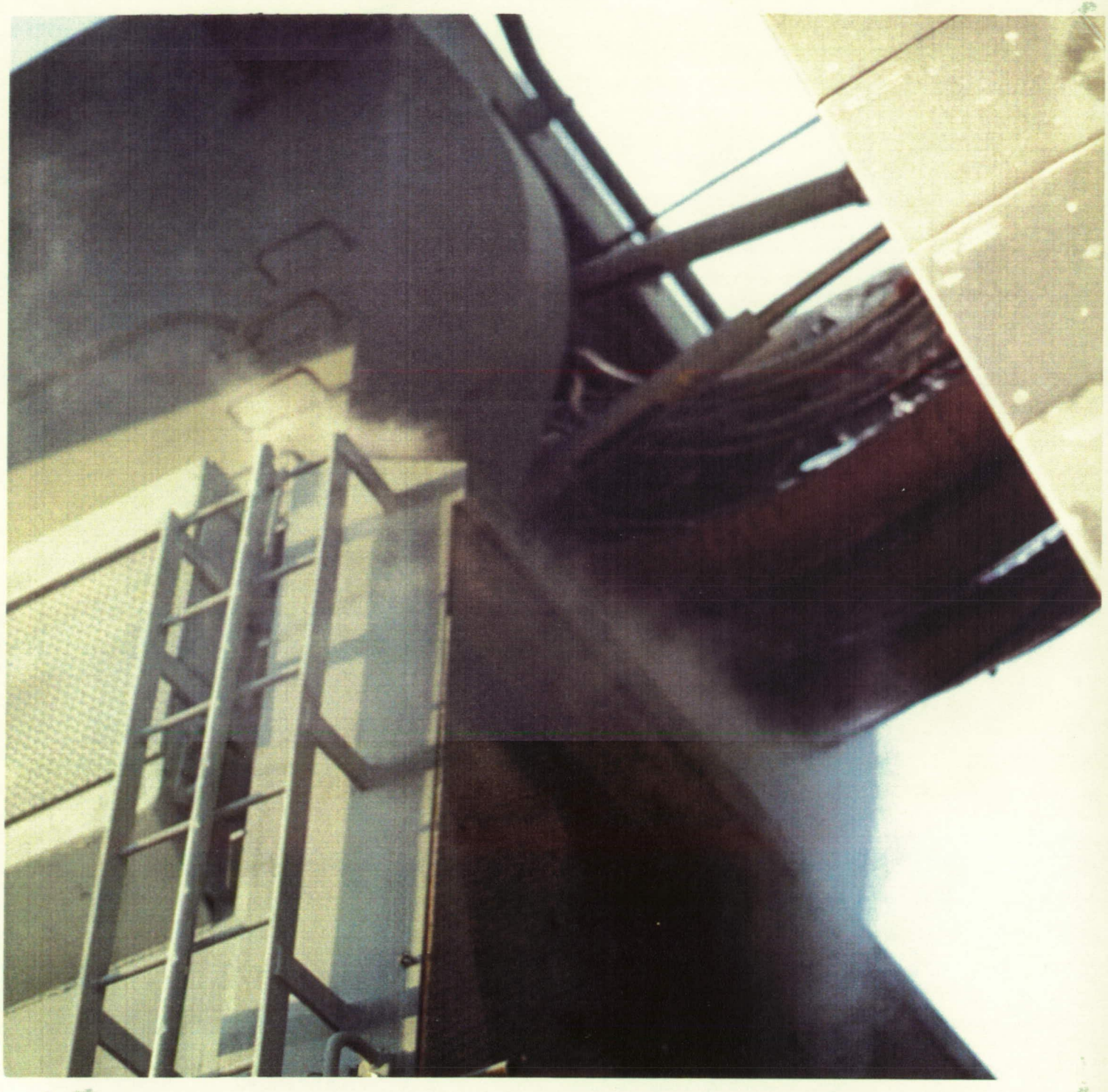

Infrared scanners measured LO2 TSM wall temperatures an average of 8 degrees cooler than similar places on the LH2 TSM walls. In addition, condensate was present on the LO2 TSM walls from the MLP deck level to half the height of the TSM. The launch team determined a liquid oxygen leak inside the TSM would not be a constraint to launch.

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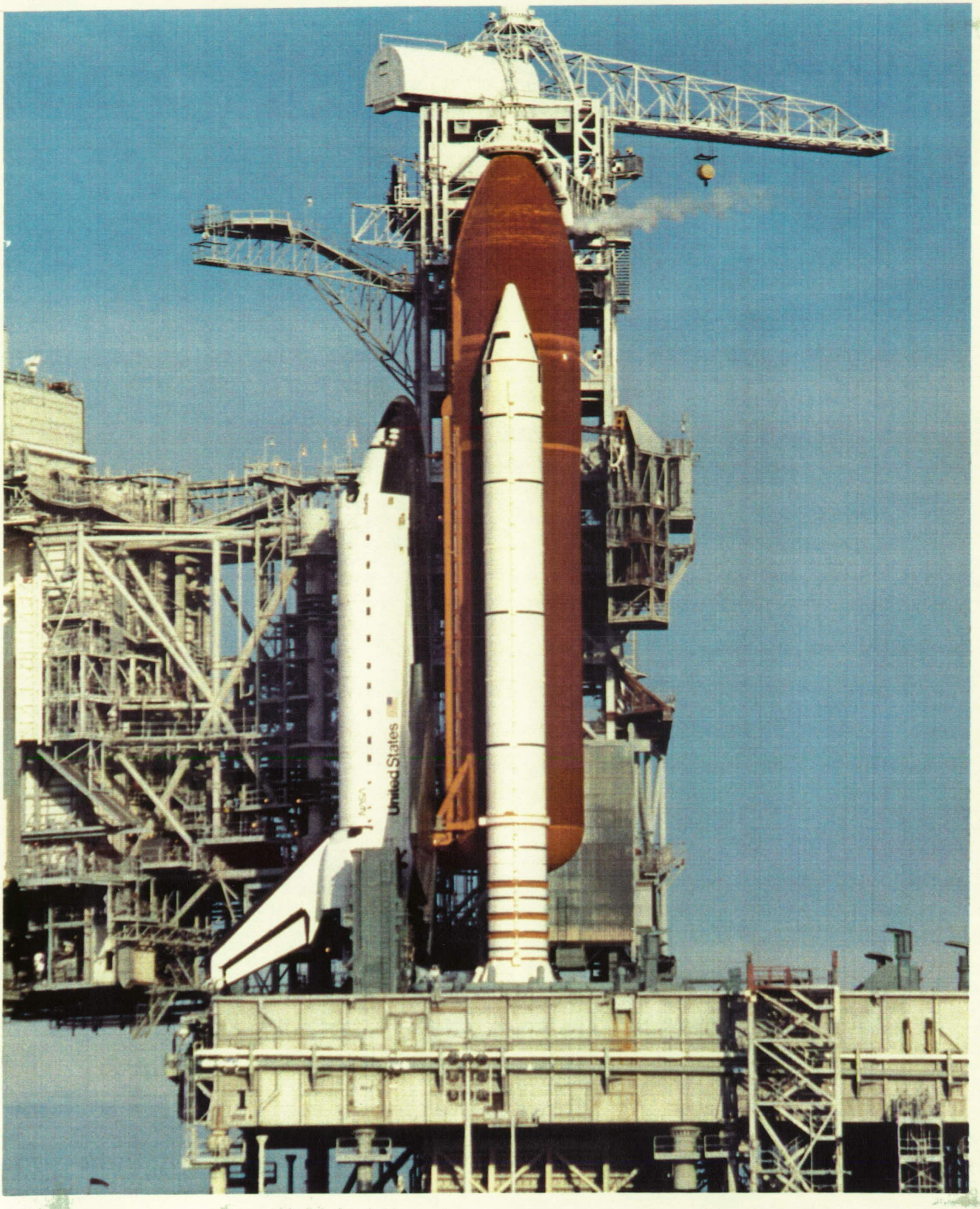

The launch of STS-43 was scrubbed due to unacceptable RTLS weather conditions at the Shuttle Landing Facility

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4.7 POST DRAIN INSPECTION

The STS-43 launch was scrubbed due to unacceptable RTLS weather conditions. The LH2 and LO2 tanks had been filled to 100 percent (stable replenish). A post-drain walkdown of the SSV and the MLP was performed at Pad-39A from 1745 to 1930 hours on 1 August 1991.

Most of the protuberance ice that had been visible on OTV during cryogenic loading had melted by the time the inspection was performed. There was no visible TPS damage, such as divots or cracks, on the ET LO2 tank, Intertank, or LH2 tank acreage.

The tumble valve cover was intact. There were no anomalies on the -Y side of the nosecone, fairing, louver, and footprint area. The +Y side of the nosecone was not accessible for inspection.

Both bipod jack pad closeouts were intact. There was no evidence of debonds or cracks, even though a small ice/frost ball had formed on each of the closeouts during LH2 drain.

Small amounts of ice were still present in the LO2 feedline support brackets. None of the brackets appeared to have damaged or loose foam. Some ice remained in all LO2 feedline bellows.

No cracks were visible in either thrust strut-to-longeron interfaces. The 1.5"x1" area adjacent to the thickness-check closeout in the aft +Z corner of the +Y longeron was still protruding with 1/8-inch offset. A 1"x2" piece of gray tape adhered to the -Y longeron approximately two feet aft of the thrust strut-to-longeron interface.

Neither the LO2 nor LH2 ET/ORB umbilicals exhibited TPS anomalies or unusual ice/frost accumulations. Ice fingers, 1-3 inches in length, remained on the umbilical pyrotechnic canister purge vents. There was no ice or frost on the 17-inch flapper valve actuator access port closeout. Some ice remained in the LH2 feedline and recirculation line bellows.

Ice was still present in both left and right SRB cable tray to upper strut fairing interfaces. EB-7 and EB-8 fittings were still covered with ice.

The aft hard point closeout had two very small areas of ice/frost inside two accepted surface voids, but was otherwise intact.

There were no visible TPS anomalies on the LH2 aft dome apex and none of the SLA vent/plug pull repairs were protruding. No TPS defects appeared on the manhole cover closeout rings, even though there was frost on the siphon cover leak check port

closeout and froth in two places of the manhole access cover (one at the leak check port closeout and one 180 degrees from the closeout).

All ice formations fell within the established data base and were acceptable per NSTS-08303.

No anomalies were visible on the Orbiter or SRB TPS.

The SRB sound suppression water trough third from the north in the LH SRB exhaust hole was torn at the east end and was empty of all water. All the other water troughs were configured correctly. There were no other facility discrepancies.

The summary of Ice/Frost Team observations/anomalies consisted of 3 OTV recorded items:

Anomaly 006 documented a frost ball and vapors from the -Y jack pad closeout during drain. The frost formation fell off the vehicle after two minutes. Post drain inspection revealed no visible TPS defect.

Anomaly 007 recorded a frost ball and vapors from the -Y bipod ramp during drain. The frost formation fell off the vehicle and the vapors stopped after two minutes. Post drain inspection revealed no visible TPS defect. The frost spot reappeared during cryogenic loading on 2 August 1991. The frost formation was acceptable per NSTS-08303.

Anomaly 008 documented a frost ball and vapors from the +Y jack pad closeout during drain. The frost formation fell off the vehicle and the vapors stopped after a few minutes. Post drain inspection revealed no visible TPS defect.

The tumble valve cover was intact. There were no anomalies on the -Y side of the nosecone, fairing, louver, and footprint area. The nosecone +Y side was not accessible for inspection.

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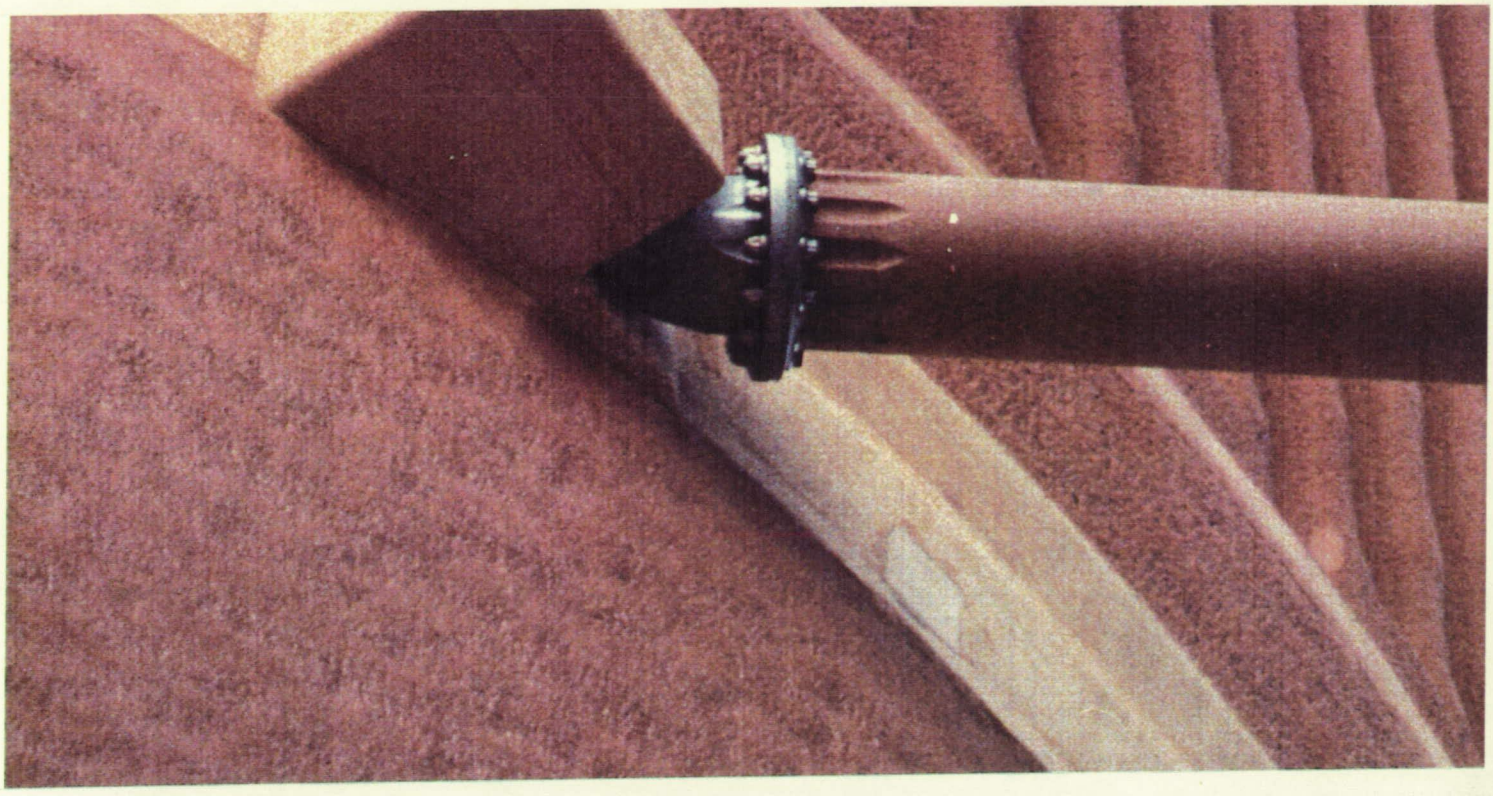

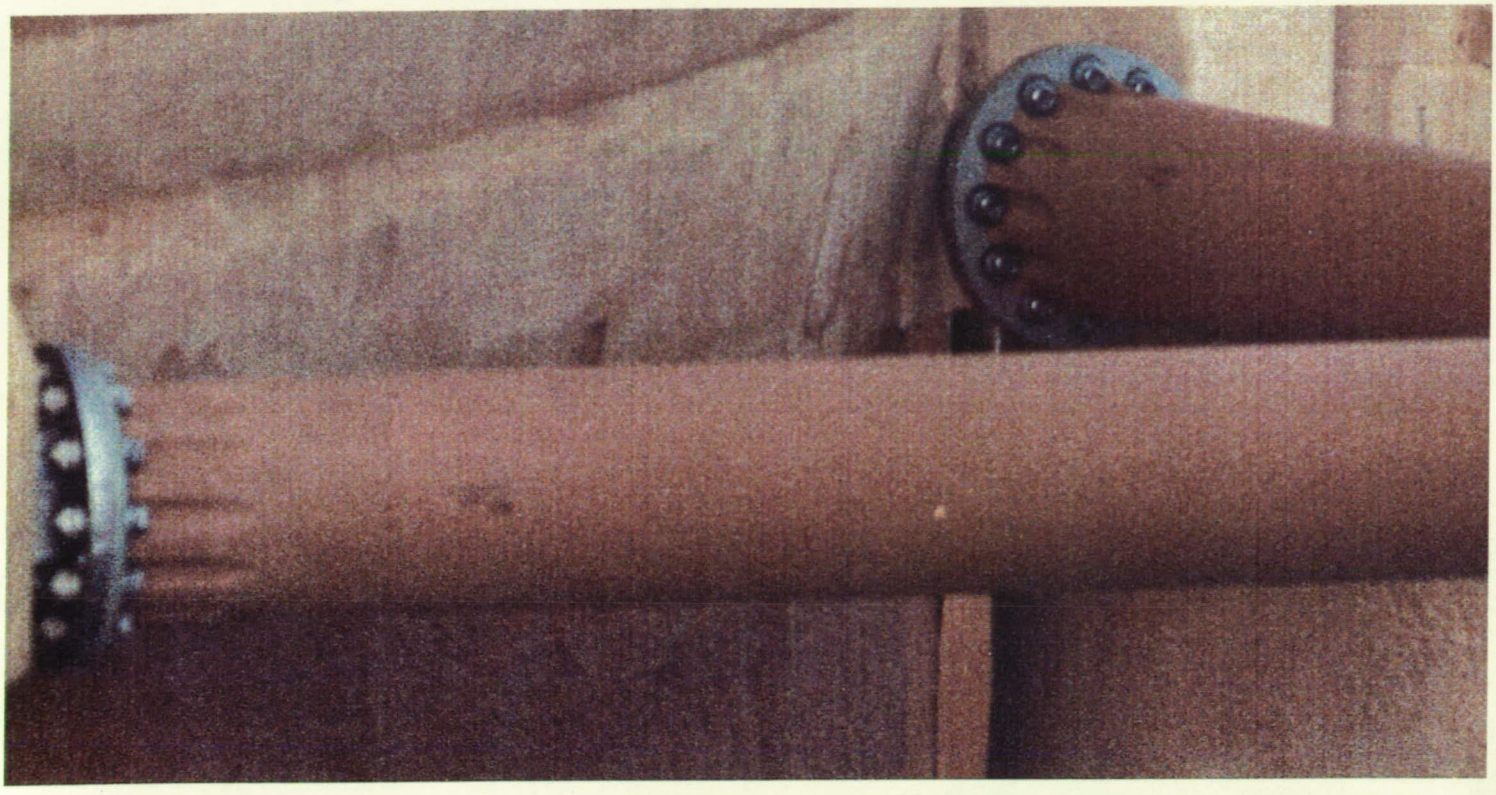

Both bipod jack pad closeouts were intact after cryo load

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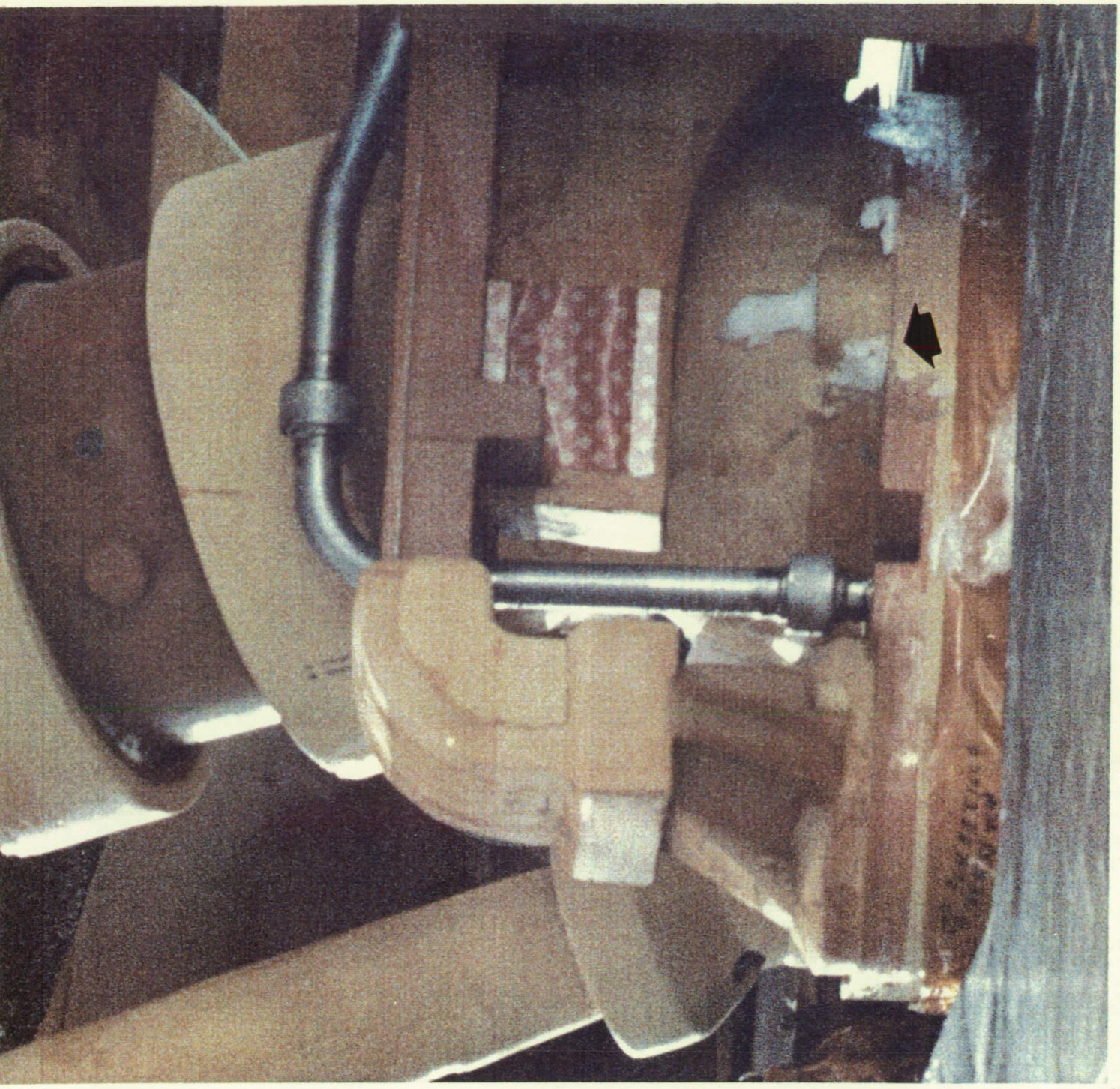

The LH2 ET/ORB umbilical exhibited no TPS anomalies or unusual ice/frost accumulations after cryo load with the exception of an ice/frost formation along the bondline of the forward outboard pyro canister closeout (aft side). This condition was acceptable per NSTS-08303.

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5.0 LAUNCH

STS-43 was launched at 2:15:01.986 GMT (11:02 a.m. local) on August 2, 1991.

5.1 ICE/FROST INSPECTION

The Ice/Frost Inspection of the cryoloaded vehicle was performed on 2 August 1991 from 0555 to 0740 hours during the two hour built-in-hold at T-3 hours in the countdown. There were no Launch Commit Criteria, OMRS, or NSTS-08303 violations. There were no conditions outside of the established data base. Ambient weather conditions at the time of the inspection were:

Temperature:	69.6 F
Relative Humidity:	95.5 %
Wind Speed:	5.4 Knots
Wind Direction:	159 Degrees

An infrared radiometer was utilized to obtain surface temperature measurements for an overall thermal assessment of the vehicle, as shown in Figure 5 and 6.

5.2 ORBITER

No Orbiter tile anomalies were observed. All RCS paper covers were wet or dry after being wet. The covers were intact and attached to the thrusters. There was no evidence of a leak or a liquid level line on any of the RCS paper covers. The water spray boiler plugs were intact. The average Orbiter surface temperature was 75 degrees F. The average surface temperatures of the SSME engine mounted heat shields were measured at 69 degrees F for SSME #1, 70 degrees F for SSME #2, and 73 degrees F for SSME #3. All of the SSME heat shields were wet with some condensate. Light frost coated the SSME #1 heat shield-to-nozzle interface at the 2-7 o'clock position and the SSME #2 heat shield-to-nozzle interface at the 2-10 o'clock position. One of the SSME drain lines on SSME #2 was covered by frost. No GOX vapors originated from inside the SSME nozzles. Some condensate was present on base heat shield tiles between SSME #2 and #3 and outboard of SSME #2.

5.3 SOLID ROCKET BOOSTERS

No SRB anomalies or loose ablator/cork were observed. The K5NA closeouts of the aft booster stiffener ring splice plates were intact. The Cyclops infrared radiometer recorded RH and LH SRB case surface temperatures between 76 and 79 degrees F. The Mikron IR radiometer gave measurements between 72 and 76 degrees F. In comparison, the GEI gave readings between 78 and 82 degrees F. The predicted Propellant Mean Bulk Temperature (PMBT) supplied by MTI was 83 degrees F, which was within the required range of 44-86 degrees F.

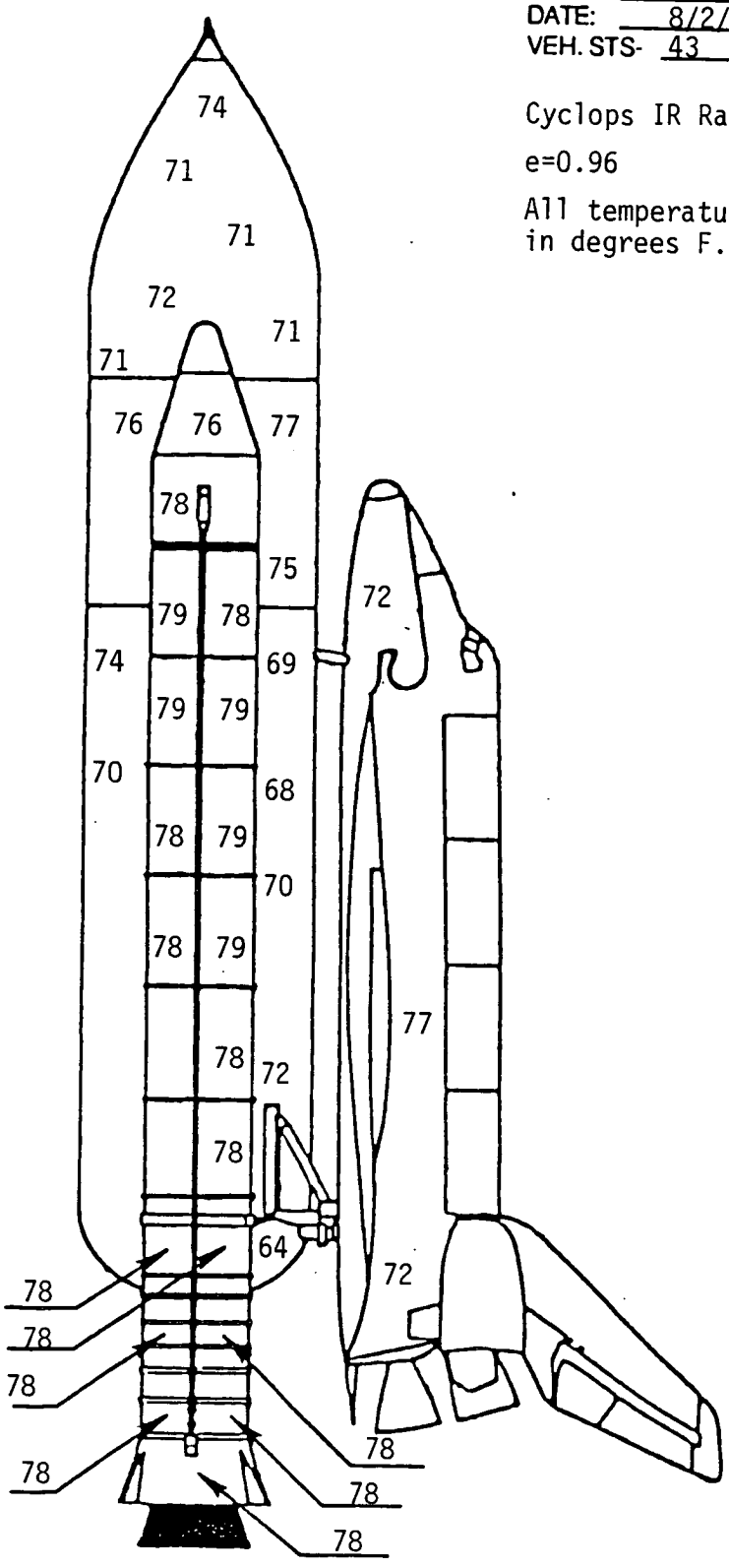
FIGURE 5. **SSV INFRARED SCANNER SURFACE TEMPERATURE SUMMARY DATA**

TIME: 0600 - 0730
DATE: 8/2/91
VEH. STS- 43

Cyclops IR Radiometer

e=0.96

All temperatures are in degrees F.



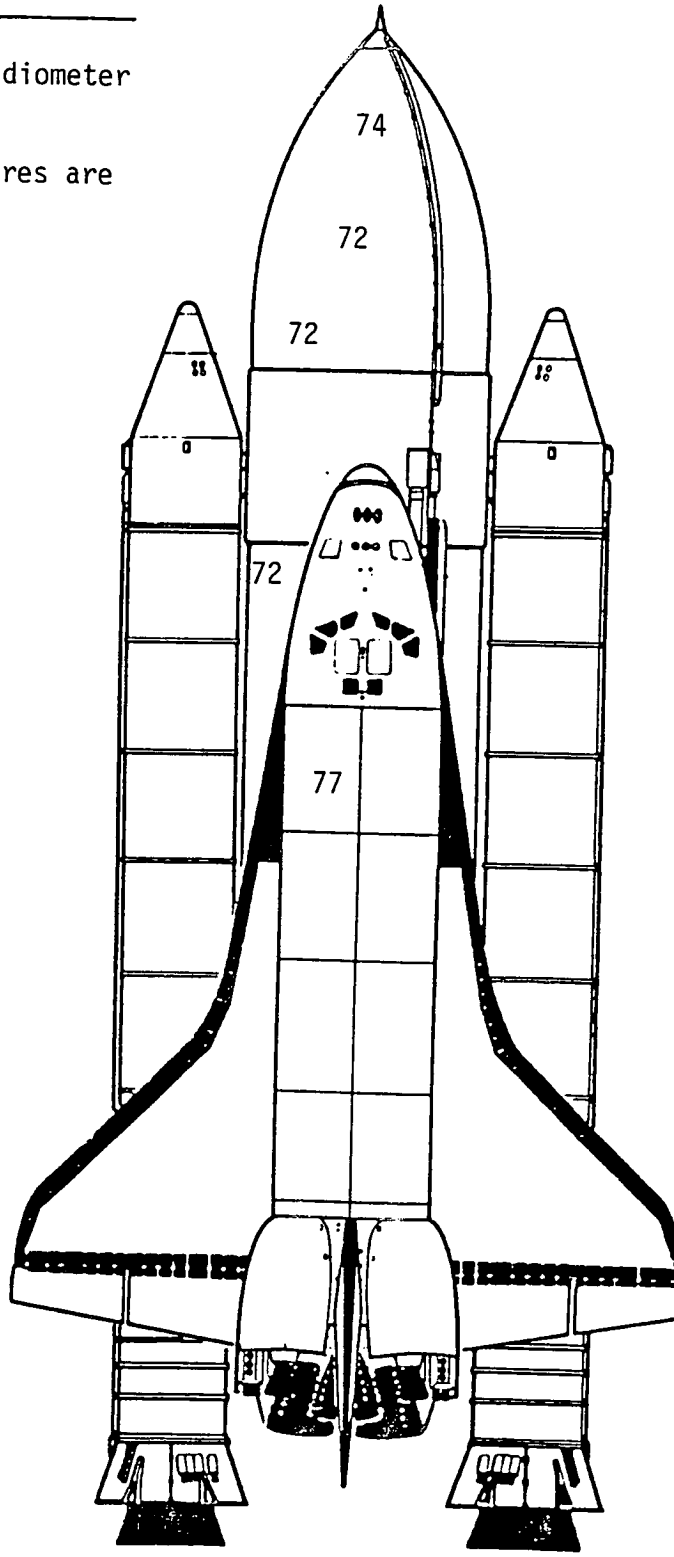


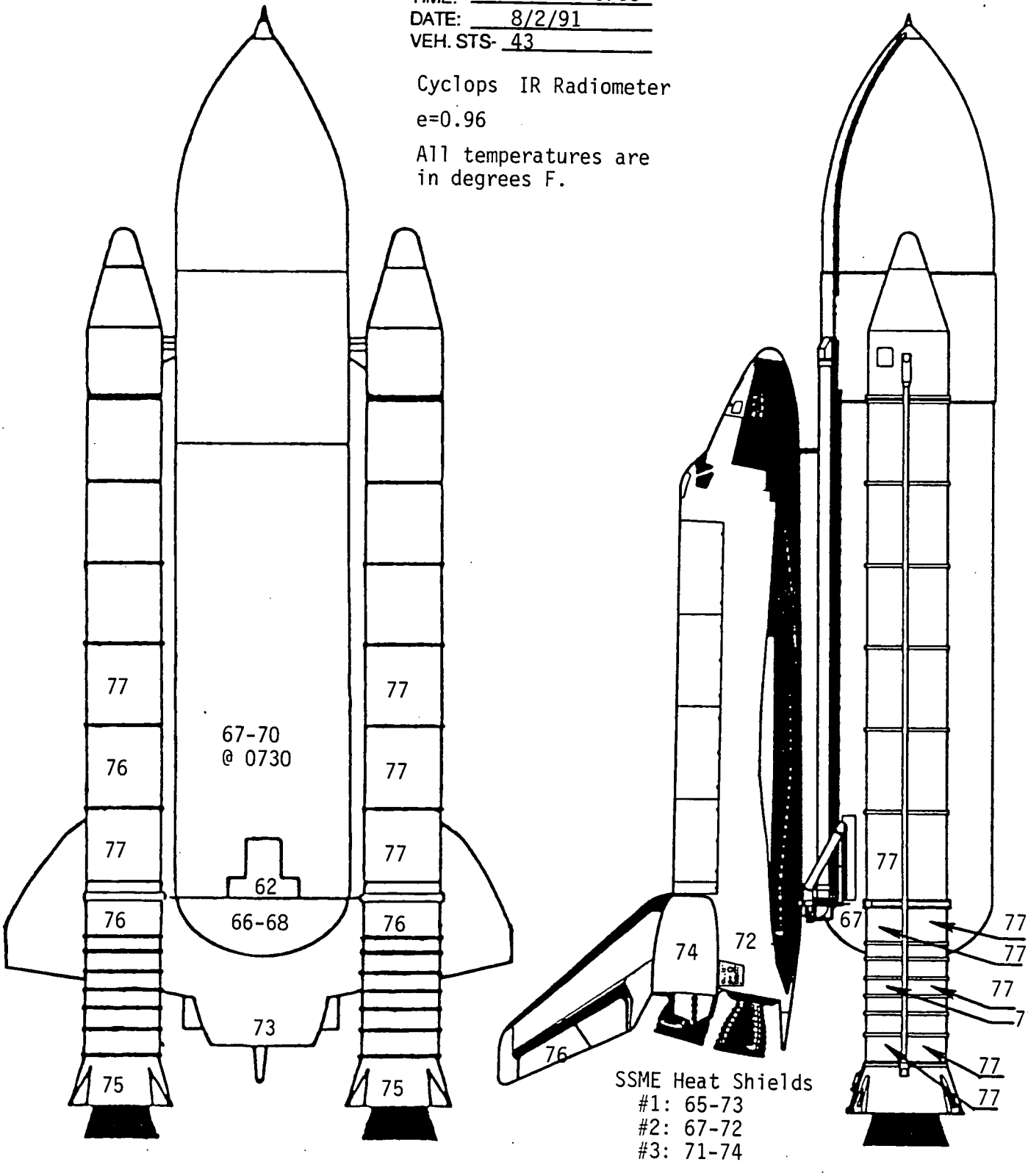
FIGURE 6. **SSV INFRARED SCANNER SURFACE TEMPERATURE SUMMARY DATA**

TIME: 0600 - 0730
DATE: 8/2/91
VEH. STS- 43

Cyclops IR Radiometer

e=0.96

All temperatures are in degrees F.



EGG/V-343C

5.4 EXTERNAL TANK

The ice/frost prediction computer program 'SURFICE' was run from 0330 to 1100 hours and the results tabulated in Figures 7 and 8. The program predicted condensate with no ice accumulation on all TPS acreage surfaces.

Very light condensate, but no ice or frost, was present on the LO2 tank barrel TPS acreage. There was no ice/frost or condensate on the LO2 tank ogive. There were no TPS anomalies. The tumble valve cover was intact. There were no anomalies on the pressurization line and support ramps. The stationary STI unit on the RSS roof measured a surface temperature of 74 degrees F on the ogive and 69 degrees F on the barrel section. SURFICE predicted 68 degrees F on the ogive and 63 degrees F on the barrel section. The Cyclops IR radiometer measured 74 and 72 degrees F, respectively.

The intertank TPS acreage was wet with light run-off condensate. There were no TPS anomalies. Numerous small scattered frost spots appeared in the stringer valleys at both LH2 and LO2 tank -Z flanges. Vapors emanated from three of the frost spots. No cryogenic drips or unusual ice formations were present on the ET umbilical carrier plate. The RSS STI infrared scanner measured an average surface temperature of 75 degrees F compared to a Cyclops IR radiometer measurement of 76 degrees Fahrenheit.

The LH2 tank and aft dome TPS acreage were covered with a moderate amount of condensate. There was no ice/frost on the acreage. The average surface temperatures as measured by the RSS STI IR scanner were 69 degrees F on the upper LH2 tank and 72 degrees F on the lower LH2 tank compared to a Cyclops IR radiometer measurement of 70 and 68 degrees F, respectively. SURFICE predicted 53 degrees F on the upper LH2 tank and 67 degrees F on the lower LH2 tank.

There were no anomalies on the bipods, jack pads, PAL ramp, cable tray/press line ice/frost ramps, thrust struts, manhole covers, or aft dome apex with the exception of a small ice/frost spot at +Z manhole cover plug repair, a frost line on the -Y longeron, and a small frost spot on the aft surface of the +Y bipod closeout. The +Y longeron exhibited a frost spot along a knit line (no crack in the TPS), but no ice or frost was present on the area that had previously delaminated. Some ice/frost was present in the ET/SRB cable tray-to-upper strut fairing expansion joints. Ice/frost covered the lower EB fittings outboard to the strut pin hole with condensate on the rest of the fitting. The struts were dry.

Typical amounts of hard, crusty ice were present in all LO2 feedline bellows and support brackets.

STS- 43	TEST S0007 LAUNCH																								NASA KSC Ice/Frost/Debris Team
ORBITER 104	ET 47	SRB BI-045	MLP 1	PAD A	LO2 CHILLDOWN TIME: 02:52 FAST FILL TIME: 03:32 SLOW FILL TIME: 03:18 REPLENISH TIME: 05:39											LH2 CHILLDOWN TIME: FAST FILL TIME: 03:13 SLOW FILL TIME: 02:51 REPLENISH TIME: 05:17										
DATE: 2 August 1991																								T-0 TIME: 11:02 DATE: 8/2/91	
TIME (EDT)	CONDITIONS					LO2 TANK STA 370 TO 540					LO2 TANK STA 550 TO 852					LH2 TANK STA 1130 TO 1380					LH2 TANK STA 1380 TO 2058				
	TEMP F	REL. HUM. %	DEW PT F	WIND VEL KNTS	WIND DIR DEG	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR
330	76.20	94.6	74.62	7	203	II	4.13	68.64	0.0034	-0.2022	II	4.13	64.15	0.0054	-0.1703	II	2.24	56.91	0.0048	-0.0880	II	9.52	69.04	0.0065	-0.3716
345	75.80	94.6	74.22	7	214	II	4.13	68.19	0.0034	-0.1988	II	4.13	63.68	0.0053	-0.1671	II	2.24	56.39	0.0048	-0.0859	II	9.52	68.59	0.0065	-0.3654
400	75.60	94.8	74.08	8	214	II	4.72	68.62	0.0035	-0.2208	II	4.72	64.54	0.0055	-0.1886	II	2.56	57.72	0.0050	-0.0980	II	10.88	69.07	0.0065	-0.4132
415	76.00	95.0	74.54	7	221	II	4.13	68.50	0.0034	-0.2012	II	4.13	64.01	0.0054	-0.1694	II	2.24	56.74	0.0048	-0.0873	II	9.52	68.91	0.0065	-0.3698
430	76.00	94.4	74.36	6	197	II	3.54	67.61	0.0033	-0.1764	II	3.54	62.55	0.0051	-0.1451	II	2.52	57.96	0.0050	-0.0982	II	2.28	56.81	0.0048	-0.0884
445	76.00	94.2	74.29	6	204	II	3.54	67.57	0.0033	-0.1761	II	3.54	62.51	0.0051	-0.1448	II	1.92	54.72	0.0045	-0.0855	II	8.16	67.88	0.0063	-0.3163
500	76.20	95.6	74.91	5	185	II	2.95	67.13	0.0033	-0.1551	II	2.95	61.38	0.0050	-0.1243	II	2.10	56.36	0.0048	-0.0881	II	1.90	55.17	0.0046	-0.0881
515	76.00	95.2	74.60	6	184	II	3.54	67.79	0.0034	-0.1776	II	3.54	62.74	0.0052	-0.1462	II	2.52	58.14	0.0050	-0.0991	II	2.28	56.99	0.0049	-0.0892
530	75.80	95.4	74.46	6	185	II	3.54	67.60	0.0034	-0.1764	II	3.54	62.54	0.0052	-0.1451	II	2.52	57.93	0.0050	-0.0981	II	2.28	56.77	0.0049	-0.0883
545	76.60	95.2	75.19	5	168	II	2.95	67.51	0.0033	-0.1573	II	2.95	61.79	0.0050	-0.1264	II	2.10	56.79	0.0048	-0.0902	II	1.90	55.61	0.0046	-0.0902
600	76.40	95.2	74.99	3	159	II	1.77	64.15	0.0029	-0.1198	II	1.77	56.13	0.0042	-0.0949	II	1.26	53.92	0.0044	-0.0889	II	1.14	53.92	0.0044	-0.0889
615	75.60	96.0	74.44	4	178	II	2.36	65.20	0.0031	-0.1271	II	2.36	58.44	0.0046	-0.0970	II	1.68	53.06	0.0043	-0.0847	II	1.52	53.05	0.0043	-0.0847
630	75.80	96.2	74.69	5	150	II	2.95	66.79	0.0033	-0.1532	II	2.95	61.02	0.0050	-0.1225	II	1.60	53.34	0.0044	-0.0861	II	6.95	67.14	0.0064	-0.2732
645	76.00	96.0	74.83	5	161	II	2.95	66.98	0.0033	-0.1543	II	2.95	61.23	0.0050	-0.1235	II	2.10	56.19	0.0048	-0.0872	II	1.90	55.00	0.0046	-0.0872
700	76.00	96.2	74.89	5	147	II	2.95	67.03	0.0033	-0.1546	II	2.95	61.27	0.0050	-0.1237	II	1.60	53.60	0.0044	-0.0874	II	6.95	67.37	0.0065	-0.2756
715	76.40	96.2	75.29	6	145	II	3.54	68.46	0.0034	-0.1821	II	3.54	63.45	0.0053	-0.1506	II	1.92	55.69	0.0047	-0.0899	II	8.34	68.92	0.0066	-0.3344
730	77.00	95.8	75.77	7	156	II	4.13	69.80	0.0035	-0.2110	II	4.13	65.39	0.0055	-0.1788	II	2.24	58.21	0.0050	-0.0935	II	9.73	70.31	0.0068	-0.3962
745	77.80	94.6	76.21	7	162	II	4.13	70.44	0.0035	-0.2158	II	4.13	66.06	0.0055	-0.1835	II	2.94	61.96	0.0054	-0.1271	II	2.66	60.89	0.0053	-0.1151
800	78.80	93.4	76.84	7	160	II	4.13	71.29	0.0034	-0.2223	II	4.13	66.97	0.0055	-0.1898	II	2.94	62.92	0.0054	-0.1322	II	2.66	61.87	0.0053	-0.1198
815	80.60	89.2	77.32	8	161	II	4.72	72.86	0.0032	-0.2566	II	4.72	69.04	0.0054	-0.2234	II	3.36	65.41	0.0054	-0.1575	II	3.04	64.46	0.0053	-0.1431
830	82.00	86.2	77.73	9	166	II	5.31	74.09	0.0030	-0.2902	II	5.31	70.67	0.0052	-0.2563	II	3.78	67.38	0.0054	-0.1821	II	3.42	66.51	0.0053	-0.1658
845	82.20	85.4	77.66	8	156	II	4.72	73.67	0.0029	-0.2637	II	4.72	69.91	0.0051	-0.2303	II	2.56	63.76	0.0049	-0.1264	II	11.12	74.01	0.0056	-0.5010
900	83.60	83.2	78.29	9	158	II	5.31	75.05	0.0027	-0.2997	II	5.31	71.69	0.0050	-0.2656	II	3.78	68.49	0.0053	-0.1895	II	3.42	67.64	0.0052	-0.1728
915	84.00	81.4	78.06	9	165	II	5.31	75.01	0.0025	-0.2992	II	5.31	71.65	0.0049	-0.2651	II	3.78	68.47	0.0051	-0.1894	II	3.42	67.62	0.0051	-0.1727
930	84.60	79.6	78.01	10	161	II	5.90	75.52	0.0023	-0.3278	II	5.90	72.45	0.0047	-0.2933	II	4.20	69.51	0.0051	-0.2101	II	3.80	68.72	0.0050	-0.1916
945	84.80	78.6	77.85	12	175	II	7.08	75.99	0.0020	-0.3807	II	7.08	73.36	0.0045	-0.3452	II	5.04	70.77	0.0050	-0.2479	II	4.56	70.07	0.0050	-0.2261
1000	85.00	78.0	77.83	11	174	II	6.49	75.79	0.0020	-0.3545	II	6.49	72.96	0.0045	-0.3195	II	4.62	70.23	0.0050	-0.2293	II	4.18	69.49	0.0049	-0.2092
1015	85.40	77.2	77.93	10	166	II	5.90	75.71	0.0020	-0.3298	II	5.90	72.66	0.0044	-0.2952	II	4.20	69.76	0.0049	-0.2119	II	3.80	68.97	0.0048	-0.1933

FIGURE 7. 'SURFICE' Computer Predictions

STS- 43	TEST S0007 LAUNCH																										
																		DATE: 2 August 1991				T-0 TIME: 11:02 DATE: 8/2/91			NASA KSC Ice/Frost/Debris Team	
ORBITER 104	ET 47	SRB BI-045	MLP 1	PAD A	LO2 CHILLDOWN TIME: 02:52 SLOW FILL TIME: 03:18						FAST FILL TIME: 03:32 REPLENISH TIME: 05:39					LH2 CHILLDOWN TIME: SLOW FILL TIME: 02:51						FAST FILL TIME: 03:13 REPLENISH TIME: 05:17					
TIME (EDT)	CONDITIONS					LO2 TANK STA 370 TO 540					LO2 TANK STA 550 TO 852					LH2 TANK STA 1130 TO 1380					LH2 TANK STA 1380 TO 2058					
	TEMP 'F	REL. HUM. %	DEW PT F	WIND VEL KNTS	WIND DIR DEG	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR
1030	85.60	76.8	77.97	12	172	II	7.08	76.33	0.0018	-0.3849	II	7.08	73.71	0.0043	-0.3493	II	5.04	71.17	0.0049	-0.2513	II	4.56	70.47	0.0049	-0.2293
1045	86.20	76.8	78.57	12	160	II	7.08	76.95	0.0018	-0.3929	II	7.08	74.36	0.0043	-0.3571	II	5.04	71.84	0.0049	-0.2573	II	4.56	71.16	0.0049	-0.2349
1100	86.40	75.6	78.31	11	174	II	6.49	76.59	0.0017	-0.3639	II	6.49	73.80	0.0042	-0.3286	II	4.62	71.13	0.0048	-0.2366	II	4.18	70.40	0.0048	-0.2161
AVG.	79.37	89.57	76.09	7.52	S		4.43	70.74				4.43	66.33				2.94	61.50				4.97	64.93		

Period of Ice Team Inspection

FIGURE 8. 'SURFICE' Computer Predictions

There were no anomalies on the LO2 ET/ORB umbilical. The purge barrier (baggie) was configured properly and was holding positive purge pressure. Small scattered accumulations of ice/frost were present of the outboard and aft areas of the baggie. There was no ice/frost accumulation on the acreage areas of the umbilical. Ice/frost fingers 4 inches in length had formed on the separation bolt pyrotechnic canister purge vents. Normal venting of nitrogen purge gas had occurred during tanking, stable replenish, and launch.

Ice/frost had formed in the LH2 recirculation line bellows and on both burst disk areas. The LH2 feedline bellows were wet with condensate. The forward and outboard sides of the LH2 ET/ORB umbilical were covered by typical ice/frost formations. Ice/ frost accumulation on the inboard and aft areas of the baggie was light. Typical ice/frost fingers had formed on the pyro canister and plate gap purge vents. A small amount of ice/frost had formed along the bondline of the aft pyro canister closeout (aft side), forward outboard pyro canister closeout (aft side), and recirculation line to umbilical closeout (aft side). These ice/frost formations were acceptable per NSTS-08303. No ice or frost was present on the cable tray vent hole. The 17-inch flapper valve actuator access port foam plug was properly closed out with no ice/frost on the bondline. Normal venting of helium purge gas had occurred during tanking, stable replenish, and launch.

One hour into cryo load (T-4:57:54 through T-4:56:36) ten to fifteen drips with vapor trails fell from the LH2 ET/ORB umbilical-to-recirculation line interface area. There was no evidence of a blowing leak, nor did the drips appear for a consistent, frequent, or extended duration. The drips fell below the field of view before completely vaporizing and behaved like liquid air rather than hydrogen. Since that area had just chilled down due to the start of recirculation, the source of the cryogenic drips was a small TPS void or defect that had cryopumped locally for a short period of time. No more cryogenic drips occurred for the remainder of cryoload, stable replenish, flight pressurization, and launch. The recommendation made by the Ice Team and accepted by the Launch Team Management was to document the event in OMI S6444 and that no IPR was required. There was no violation of OMRS S00FB0.360, which verifies that there was no cryogenic leakage or excessive vapors from the ET/ORB MPS areas.

The ET/ORB hydrogen detection sensor tygon tubing had not been re-installed on the vehicle due to the 24 hour scrub turnaround

The summary of Ice/Frost Team observations/anomalies consisted of 5 OTV recorded items:

Anomaly 009 documented ice/frost formations and vapors on the +Y longeron forward of a previously accepted area (ref PR ET-47-TS-0020). The formation appeared to be the result of a TPS defect and was acceptable per NSTS-08303.

Anomaly 010 documented localized cryopumping from the LH2 ET/ORB umbilical to LH2 recirculation line interface from T - 4:57:54 through 4:56:55 and T-4:56:42 through 4:56:36. The Ice Team assessed the condition and determined the cryogenic drips were liquid air produced by exposure to a cryogenic surface due to a localized TPS defect, such as a void or cracked bondline. The drips fell too far before vaporizing to be anything but liquid air. The dripping liquid did not represent a leak from any cryogenic component.

Anomaly 011 noted ice/frost spots (some with vapors) at the LH2 tank-to-intertank flange on the -Z side of the tank. The vapors were not excessive. These frost spots were acceptable per NSTS-08303.

Anomaly 012 recorded a small ice/frost formation at the junction of the -Y longeron clip, vertical ET/SRB cable tray, and -Y PAL ramp. The frost formed along a bondline and was acceptable per NSTS-08303.

Anomaly 013 (documentation only) noted ice/frost accumulations in the LO2 feedline brackets and bellows, LO2 ET/ORB umbilical purge vent and baggie, LH2 feedline and recirculation line bellows, and LH2 ET/ORB umbilical purge vent and baggie. All areas were acceptable per NSTS-08303.

5.5 FACILITY

No new debris concerns had been identified during the ice/frost inspection of the vehicle.

All SRB sound suppression water troughs were filled and properly configured for launch.

No leaks were observed on either the LO2 or LH2 Orbiter T-0 umbilicals, though typical accumulations of ice/frost were present on the cryogenic lines. One corner of the purge barrier in the LH2 TSM door had come loose. Excessive GOX vapors again emanated from the open LO2 TSM door and condensate was present on the walls of the TSM. The infrared devices measured 62 degrees F on the south wall of the TSM compared to a reading of 74 degrees F at a similar location on the LH2 TSM. A Launch Accessories IPR taken during the previous cryo load was still open against a suspected liquid oxygen leak inside the TSM. Internal inspection of the LO2 TSM during the 24 hour scrub turnaround revealed no obvious anomalies. The IPR was no constraint for launch.

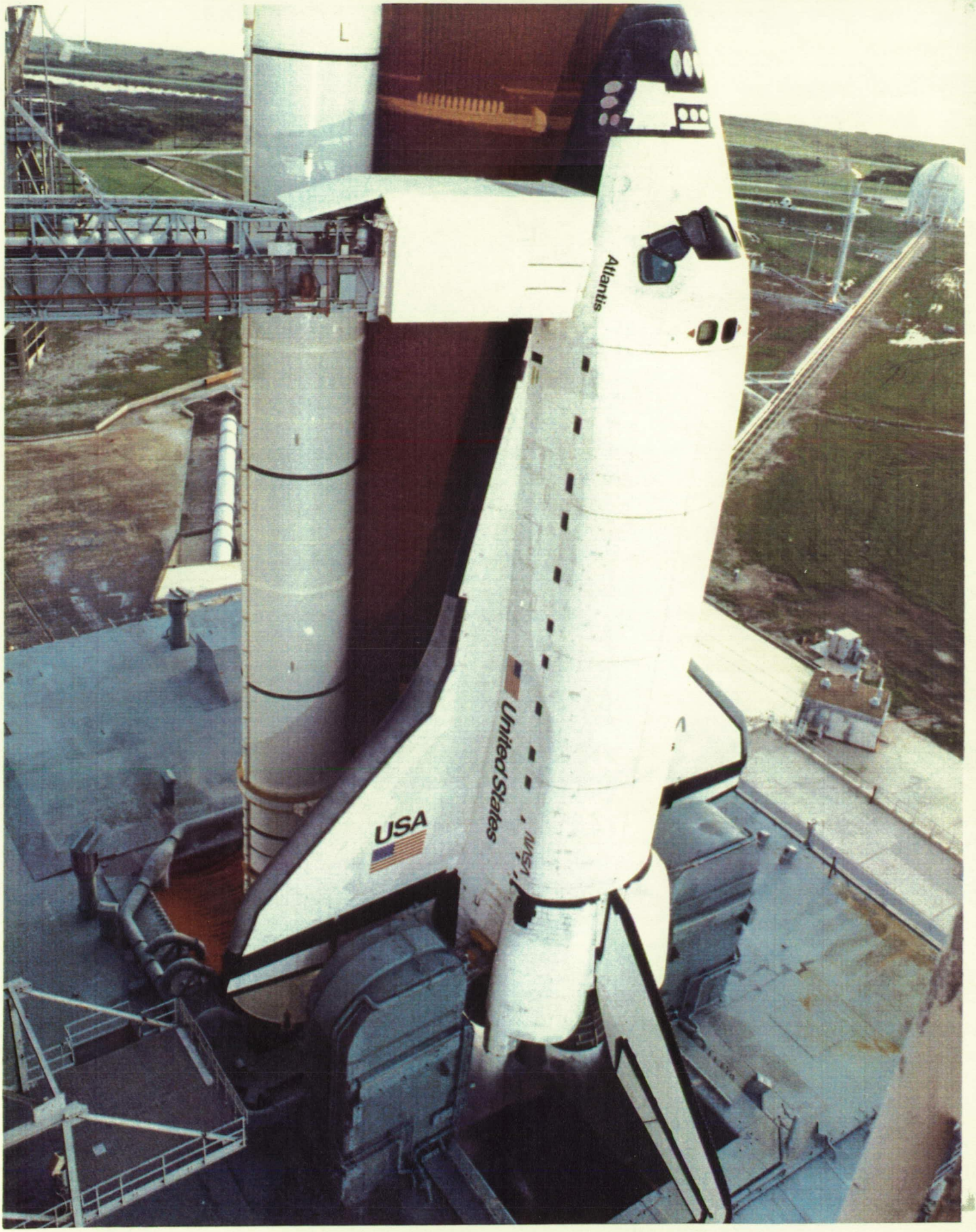
Post launch troubleshooting consisted of pressurizing the system with helium and a mass spec leak check of the joints. A large leak was detected at the 2-inch fill and drain vent line at the top of the TSM masthead where the line transitions from flexhose to hardline (KC union and "B" nuts). Two other minor leaks were detected at the 1/4-inch pressure monitor line for the 8-inch fill and drain line at the top of the masthead and at the 3/4-inch drain assist purge line for the 8-inch fill line at the bathtub bulkhead "B" nut. The 2-inch union and all seals at the three joints were replaced. All MLP-3 LOX TSM fittings that will encounter cryogenic loading during STS-48 will be torque and leak checked.

During the topping phase of hydrogen tanking, leak detectors 23 and 25 showed a rapid rise to 20,000 ppm hydrogen in the GUCP cavity purge. The leakage settled into an oscillatory pattern of 3000-4000 ppm and was similar to the previous cryo load. Externally, there was no apparent leakage anywhere on the GH2 vent line or GUCP. The modification to the GH2 vent line prevented ice from forming, but some ice/frost, which was expected, had accumulated on the GUCP legs and on the uninsulated parts of the umbilical carrier plate.

Post launch examination of the GUCP revealed the loading nut, which controls load on the bellows, was in a configuration that reduced the load between the bellows probe and the seal. This condition combined with liquid hydrogen carry over into the vent line during topping could cause a leak. In addition, the 3/8-inch QD seal supports for the nose cone and intertank purges were installed in the wrong location. The problem

appeared to be caused by procedures rather than a hardware problem. Subsequent vehicles will be inspected to verify proper configuration.

Visual and infrared observations of the GOX seals confirmed no leakage. No ET nosecone/footprint damage was visible after the GOX vent hood was retracted. There were no icicles on the GOX vent ducts.



The STS-43 stack was cryo loaded for flight on 8/2/91.
There were no Orbiter tile or SRB anomalies.

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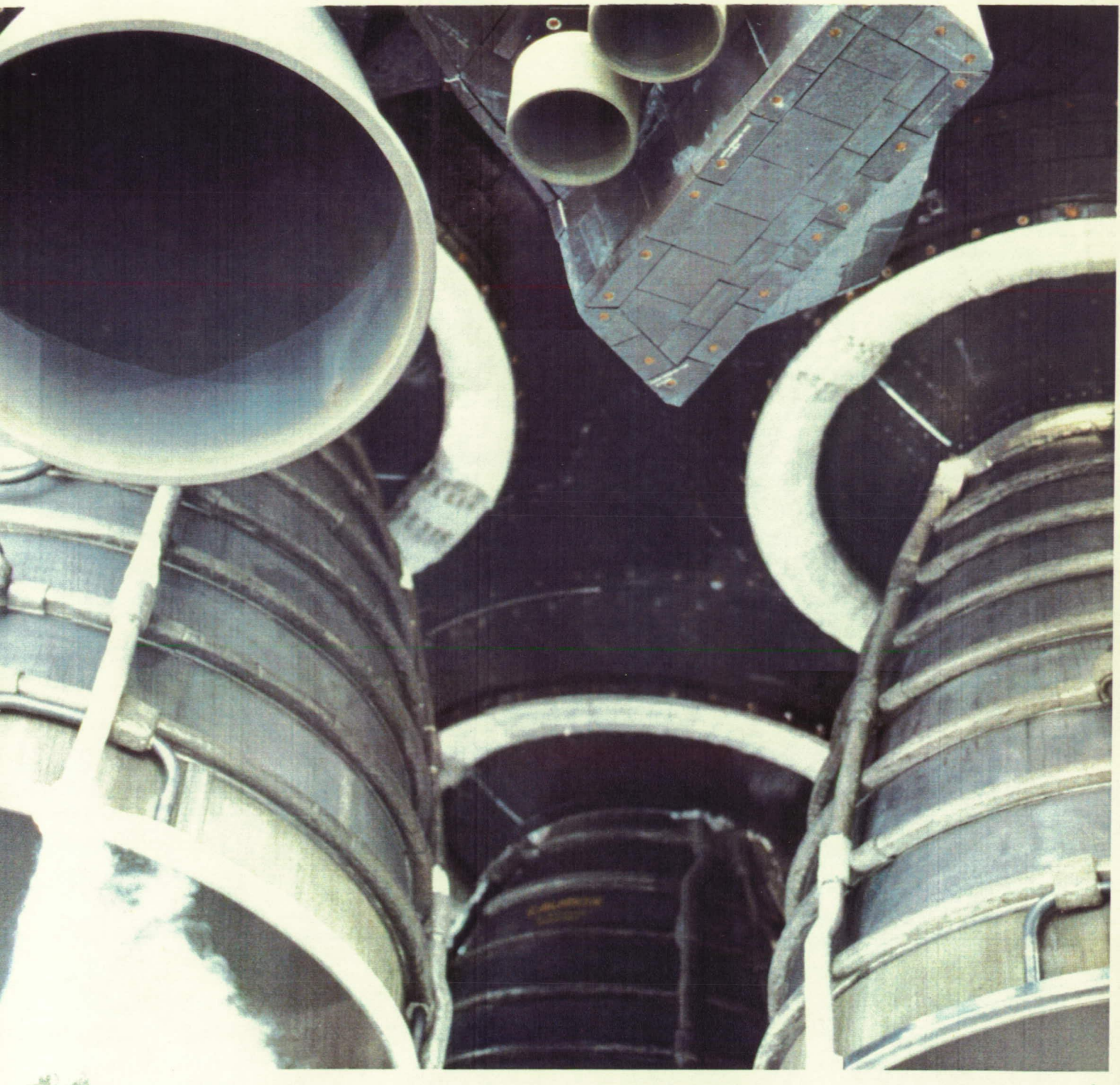

Overall view of the SSME cluster and RH OMS nozzle. Some ice/ frost had accumulated at the SSME #1 and #2 heat shield-to-nozzle interfaces.

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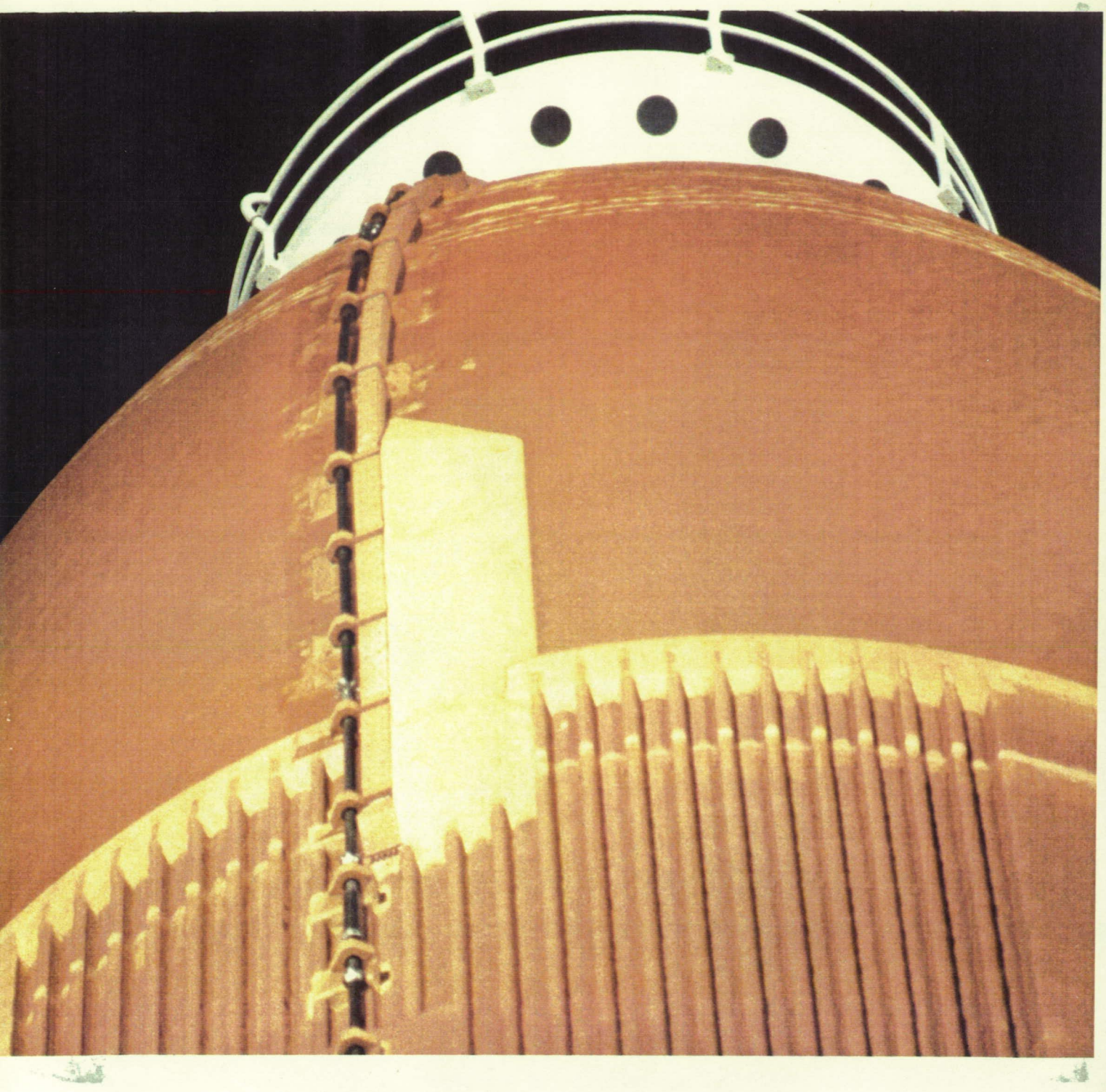

Very light condensate, but no ice or frost, was present on the LO2 tank barrel TPS acreage. There was no ice/frost or condensate on the LO2 tank ogive. There were no TPS anomalies.

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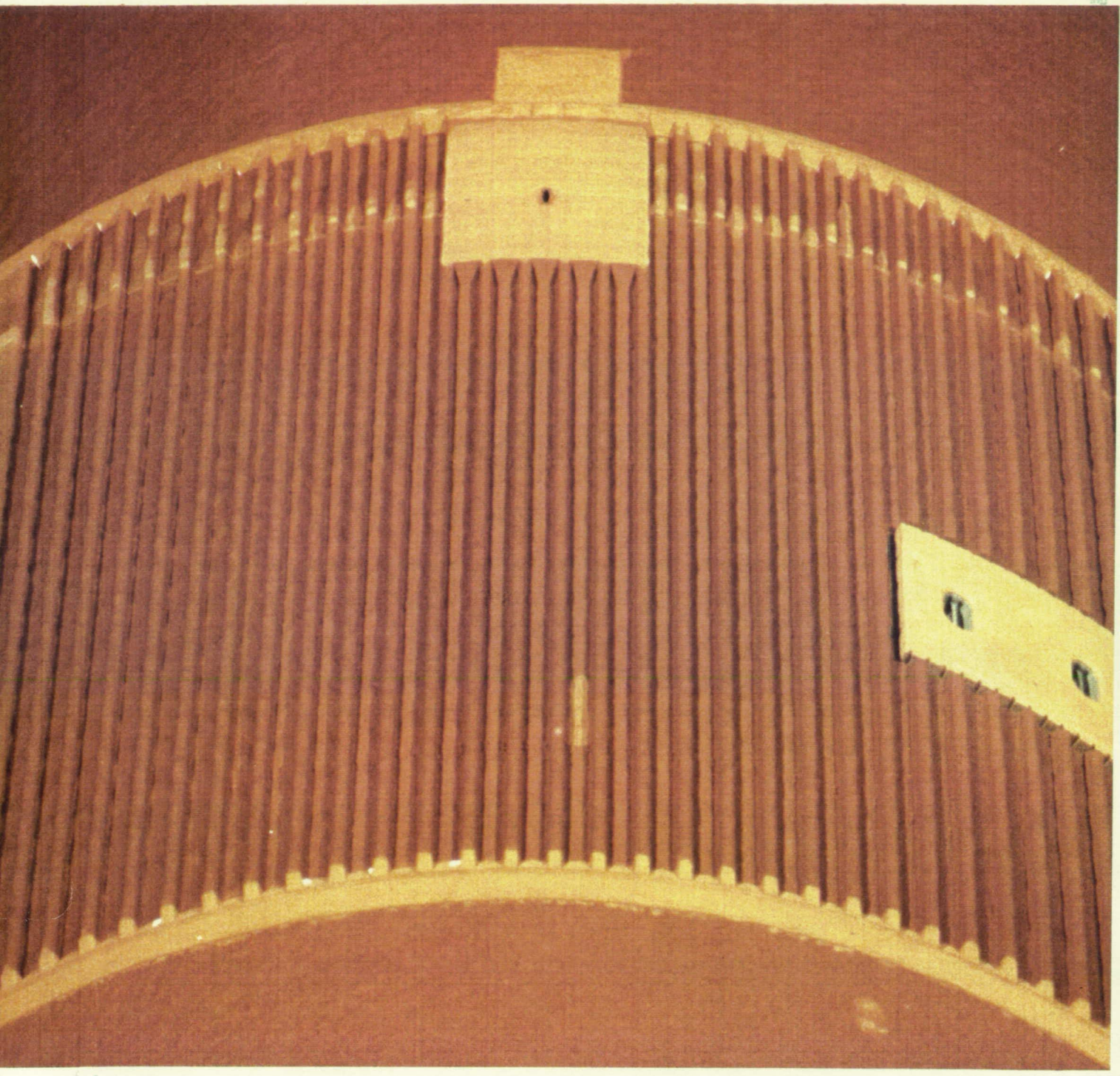

The intertank TPS acreage was wet with run-off condensate. There were no TPS anomalies. Numerous small scattered frost spots appeared in the stringer valleys at both LH2 and LO2 tank -Z flanges - an acceptable condition per NSTS-08303.

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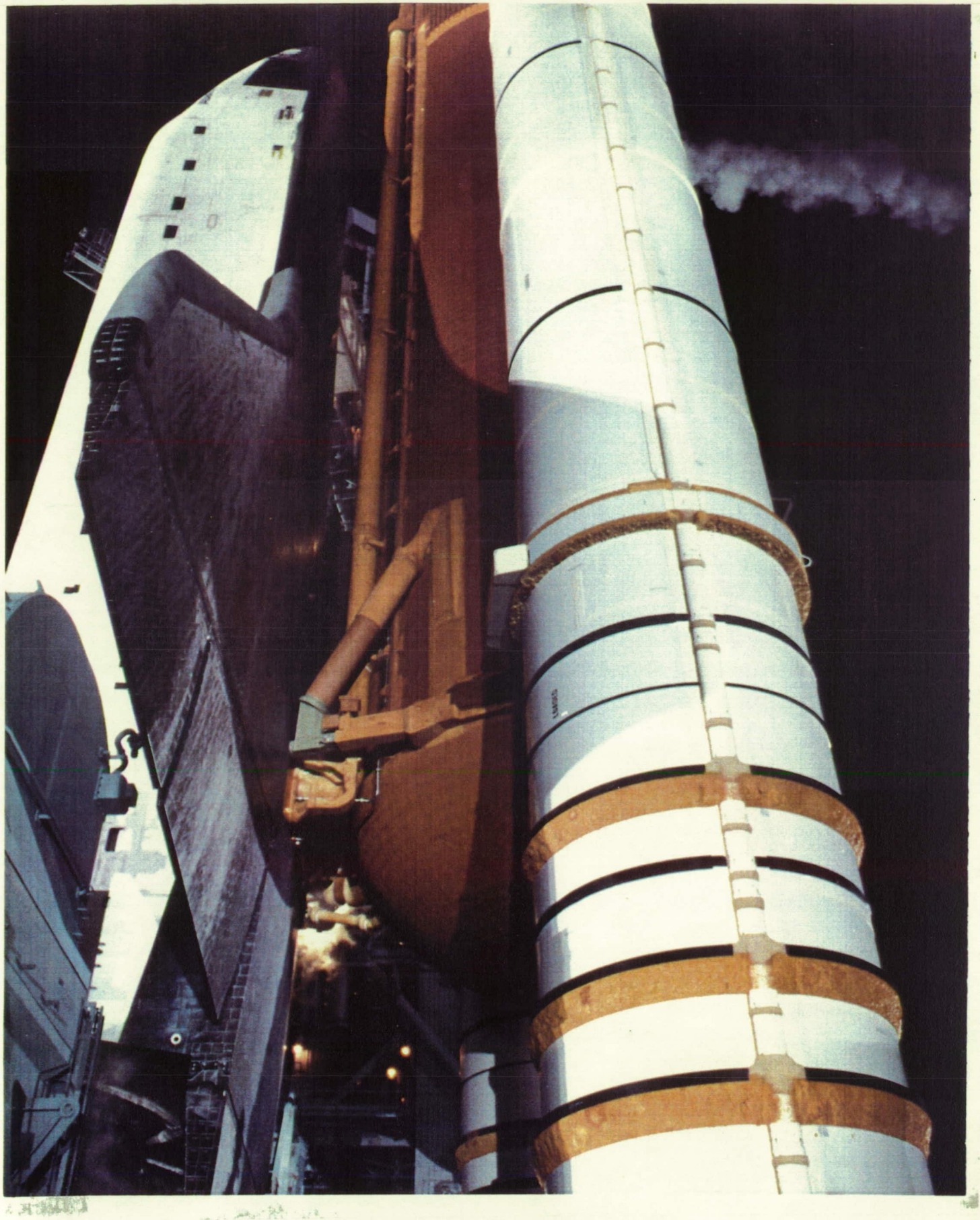

The LH2 tank and aft dome TPS acreage were covered with a moderate amount of condensate. There were no TPS anomalies or ice/frost accumulations on the acreage.

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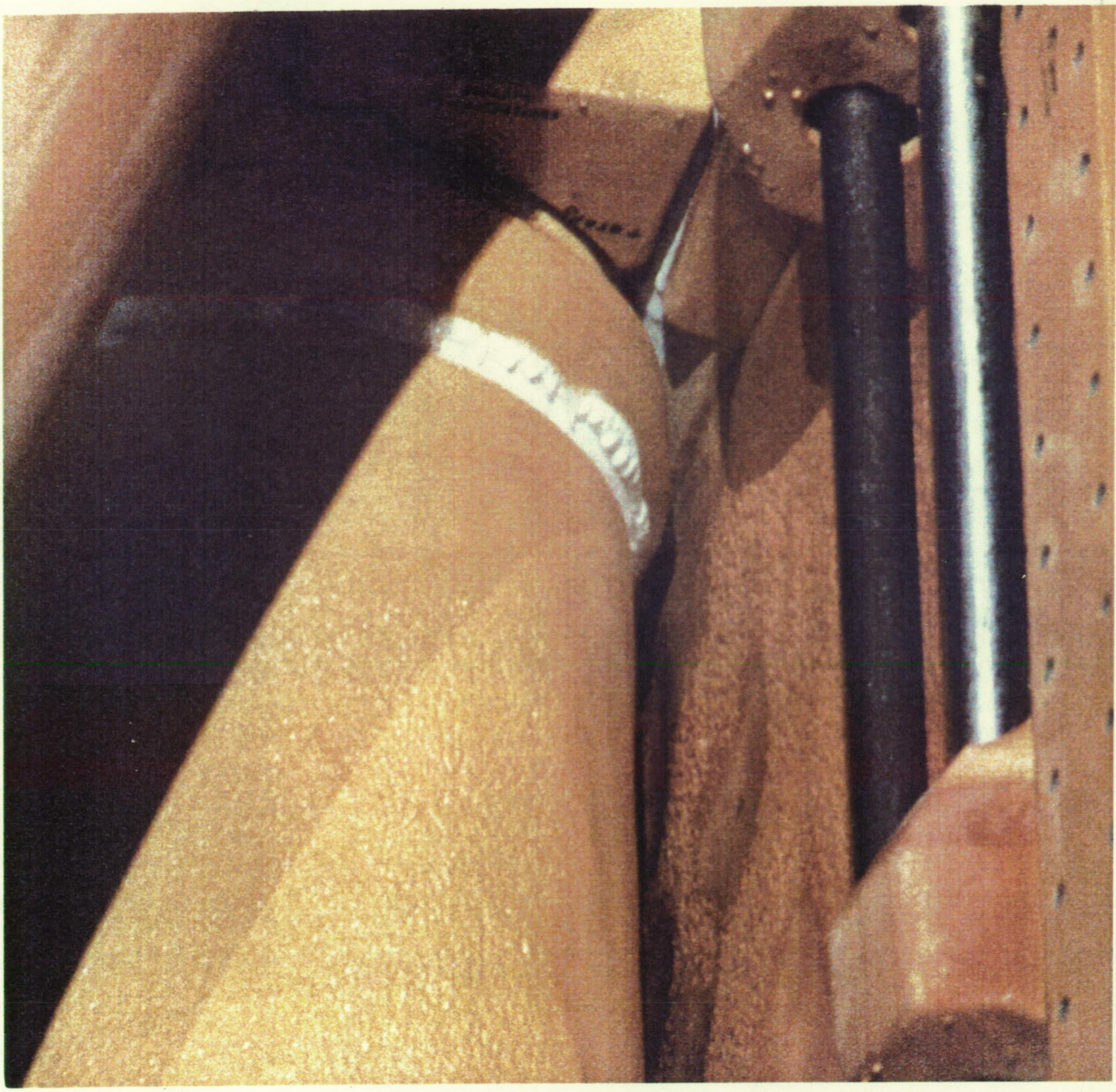

Typical amounts of hard, crusty ice were present in all
LO2 feedline bellows and support brackets

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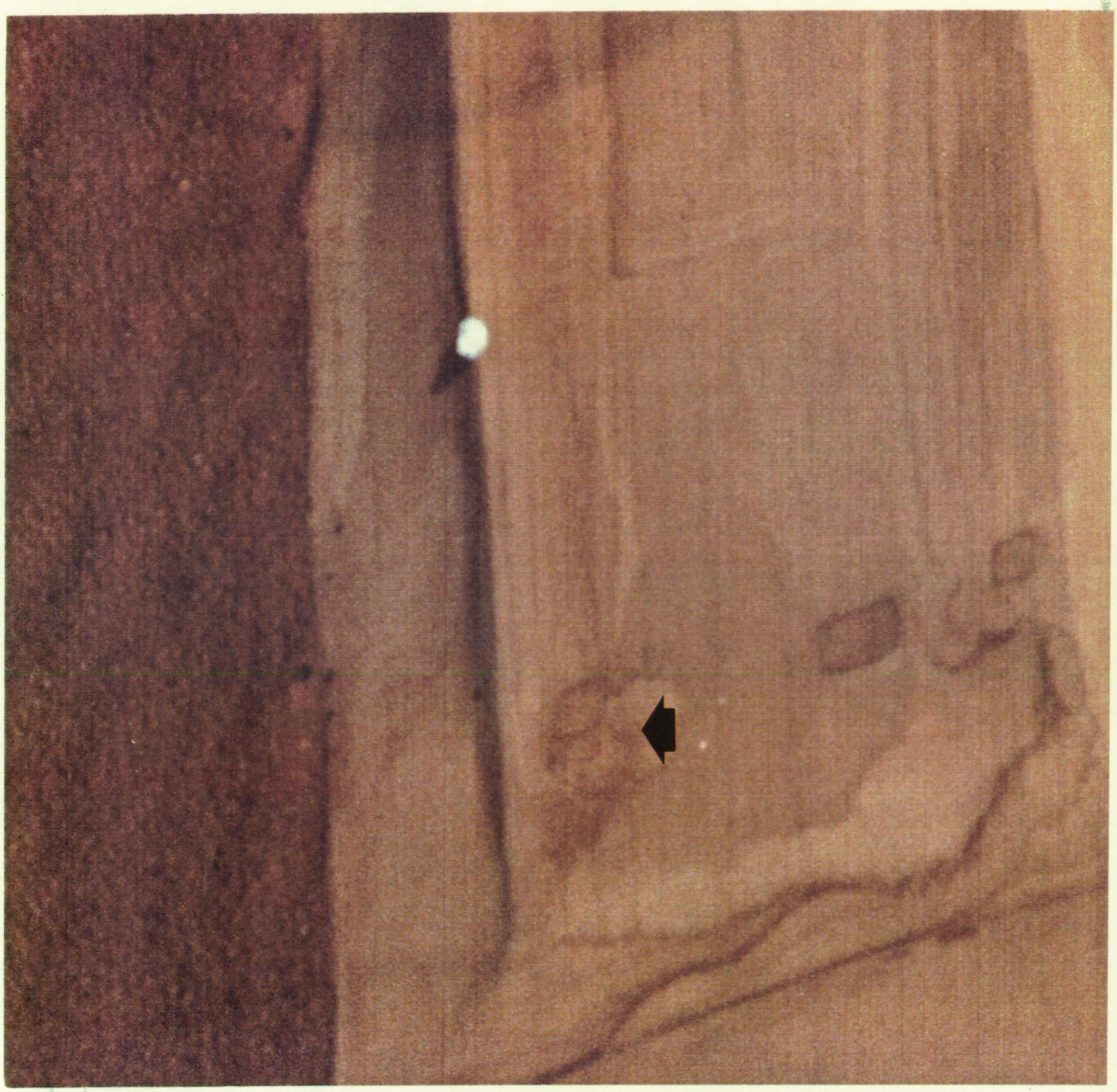

A small frost spot formed along a knit line (no crack in the TPS) on the +Y longeron, but no ice or frost was present on the area that had previously delaminated (arrow).

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There were no anomalies on the LO2 ET/ORB umbilical

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Atmospheric conditions (high humidity) caused condensate to drip from the LH2 ET/ORB umbilical onto Orbiter tiles. Normal venting of cold helium purge gas, more visible than usual, occurred during tanking, stable replenish, and launch.

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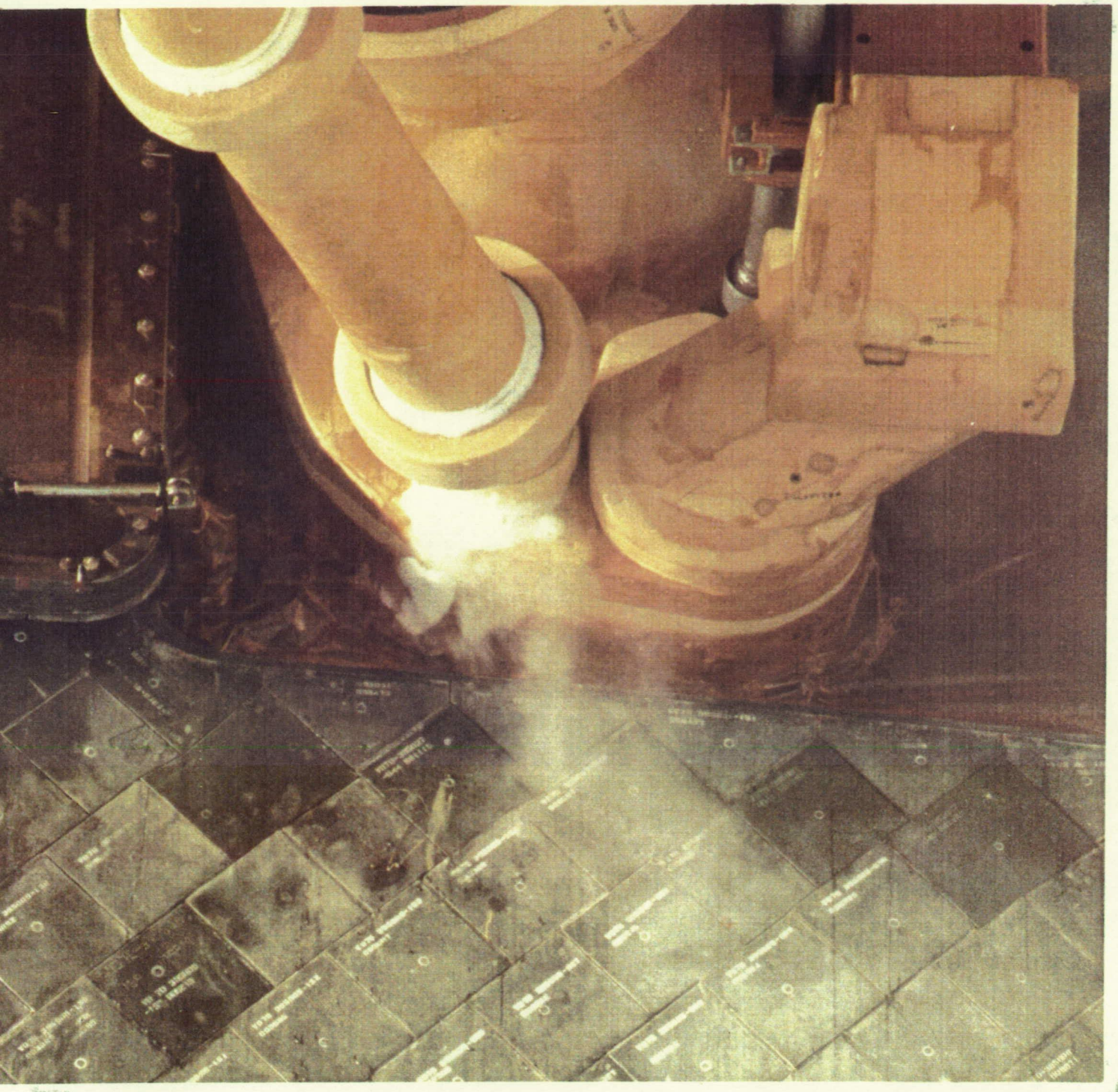

One hour into cryo load, 15 drips with vapor trails fell from the LH2 ET/ORB umbilical-to-recirculation line interface area. There was no evidence of a blowing leak, nor did the drips appear for a consistent, frequent, or extended duration. The drips behaved like liquid air rather than hydrogen. Since that area had just chilled down due to the start of recirculation, the source of the cryogenic drips was a small TPS void or defect that had cryopumped locally for a short period of time.

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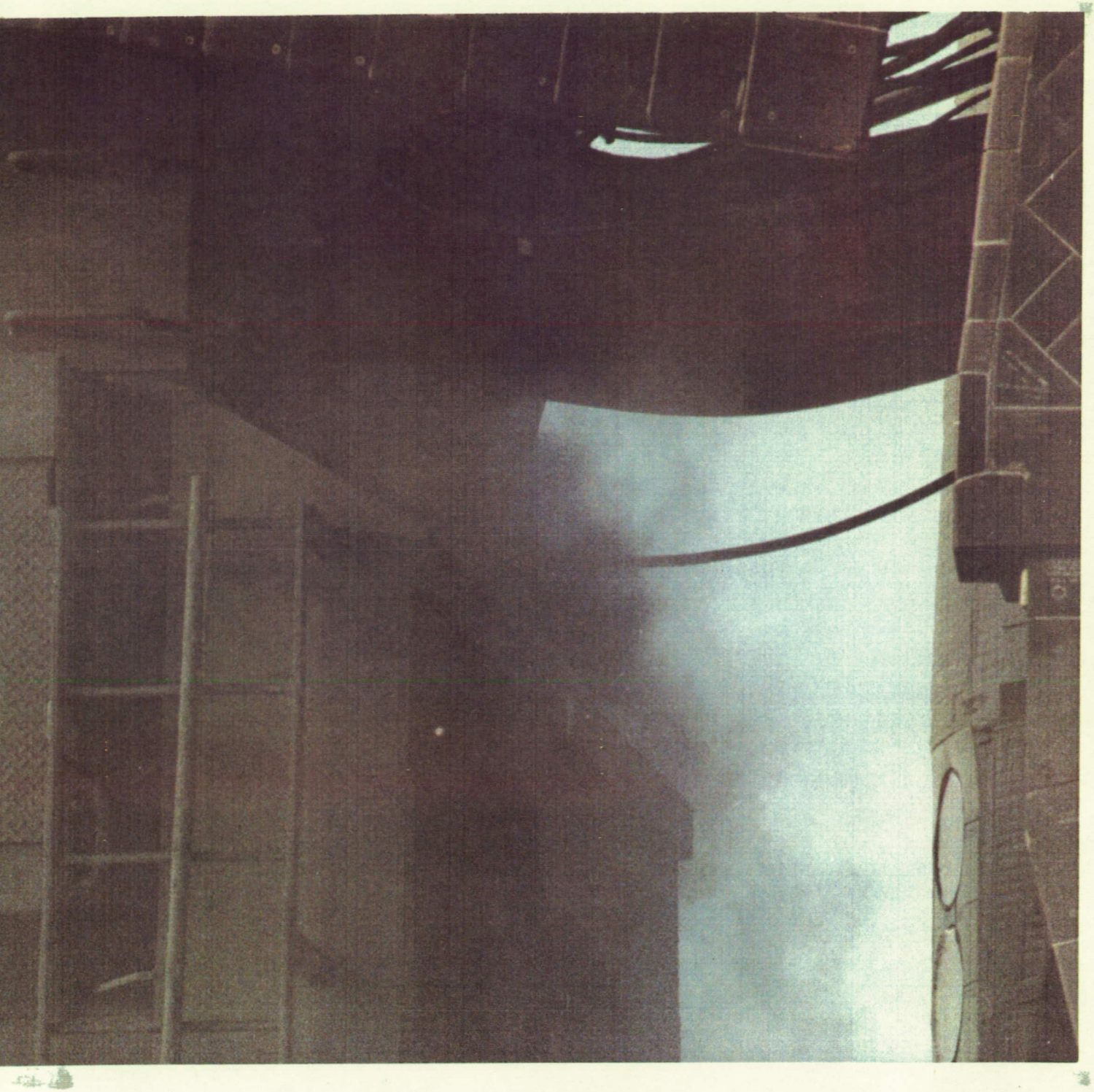

Excessive vapors again emanated from the open door of the LO2 TSM due to a liquid oxygen leak inside the TSM. The leak was not a constraint to launch. Post launch assessment revealed a large leak at the top of the TSM masthead where the line transitioned from flexhose to hardline.

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6.0 POST LAUNCH PAD DEBRIS INSPECTION

The post launch inspection of the MLP, FSS, pad surface, and pad acreage was performed on August 2-3, 1991. Two base heat shield Q-felt plugs were found at the southwest corner of the pad apron. No other flight hardware or TPS materials were found.

Plume erosion of the south SRB holddown posts was typical. All EPON shim sidewall material and shim bottom plate material was intact and bonded to the shoes. There was no visual indication of a stud hang-up on any of the south holddown posts. North holddown post doghouse blast covers were in the closed position and exhibited typical plume erosion. HDP #4 doghouse blast cover had two holes, the largest measuring 3"x1". The SRB aft skirt purge lines were in place but slightly damaged. One connector saver (sacrificial piece) on the RH SRB T-0 umbilical protruded upward 0.75 inches. The other cable connector savers on both SRB T-0 umbilicals were in place and showed normal plume impingement effects.

The OAA and TSM's showed the usual minor post launch damage. The Hydrogen Dispersal System structure was undamaged. The GOX vent arm was locked in the retracted position and exhibited minor launch damage. The GOX vent hood west window was detached at one corner. The GH2 vent arm appeared to have retracted nominally, was latched on the eighth tooth of the latching mechanism, and had no loose cables. The ET intertank access structure sustained typical plume heating effects.

Typical damage to the facility included 1) four FSS level signs detached from the west side of the elevator shaft, 2) a panel detached between elevator doors on the 115' level, 3) cabinet doors were ajar and bent, 4) one cable tray cover was found 100 yards east of the pad, and 5) one of nine light fixtures from an east stadium light was detached and found east of the pad.

No emergency egress slidewire baskets had released during launch.

Inspection of the pad perimeter was completed on 3 August 1991 along with the areas outside the pad perimeter, railroad tracks, the beach from UCS-9 to the Atlas complex, the beach access road, and the ocean areas under the vehicle flight path. No flight hardware was found.

Patrick AFB and MILA radars were configured in a mode for increased sensitivity for the purpose of observing any debris falling from the vehicle during ascent but after SRB separation (due to the masking effect of the SRB exhaust plume). Most of the signal registrations were very weak and often barely detectable, which generally compares with the types of particles detected on previous Shuttle flights. A total of 46 particles were imaged in the T+143 to 424 second time period. Thirty-one

of the particles were imaged by only one radar, 13 particles were imaged by two radars, and 2 particles were imaged by all three radars. Signal returns for the particles were in the same range that has become typical for previous missions.

Post launch pad inspection anomalies are listed in Section 11.

Post launch condition of RH SRB holddown posts

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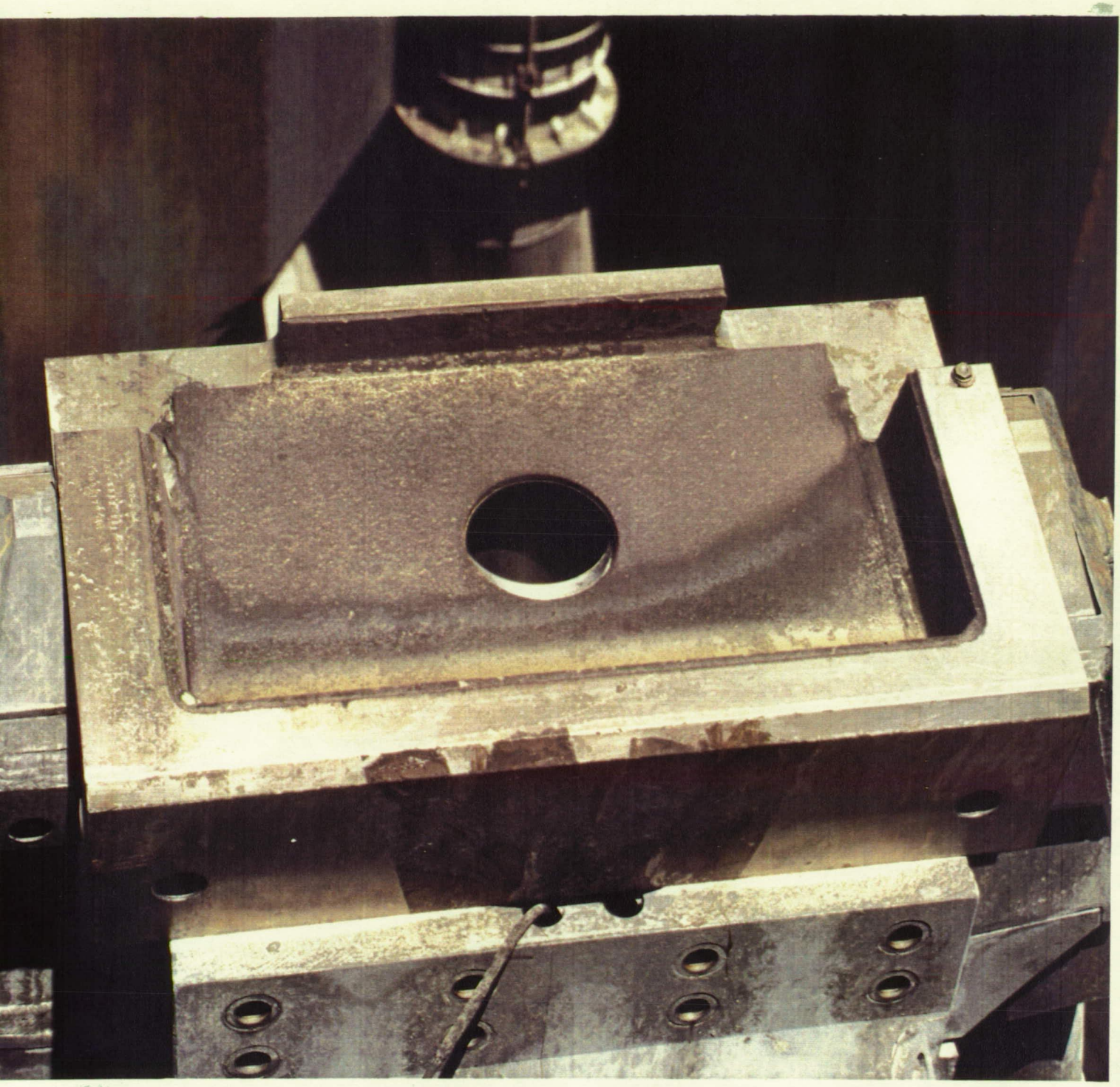

Plume erosion of the south SRB holddown posts was typical. All EPON shim sidewall material and shim bottom plate material was intact and bonded to the shoes. There was no visual indication of a stud hang-up on any of the south holddown posts.

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North HDP blast covers were in the closed position and exhibited typical plume erosion effects

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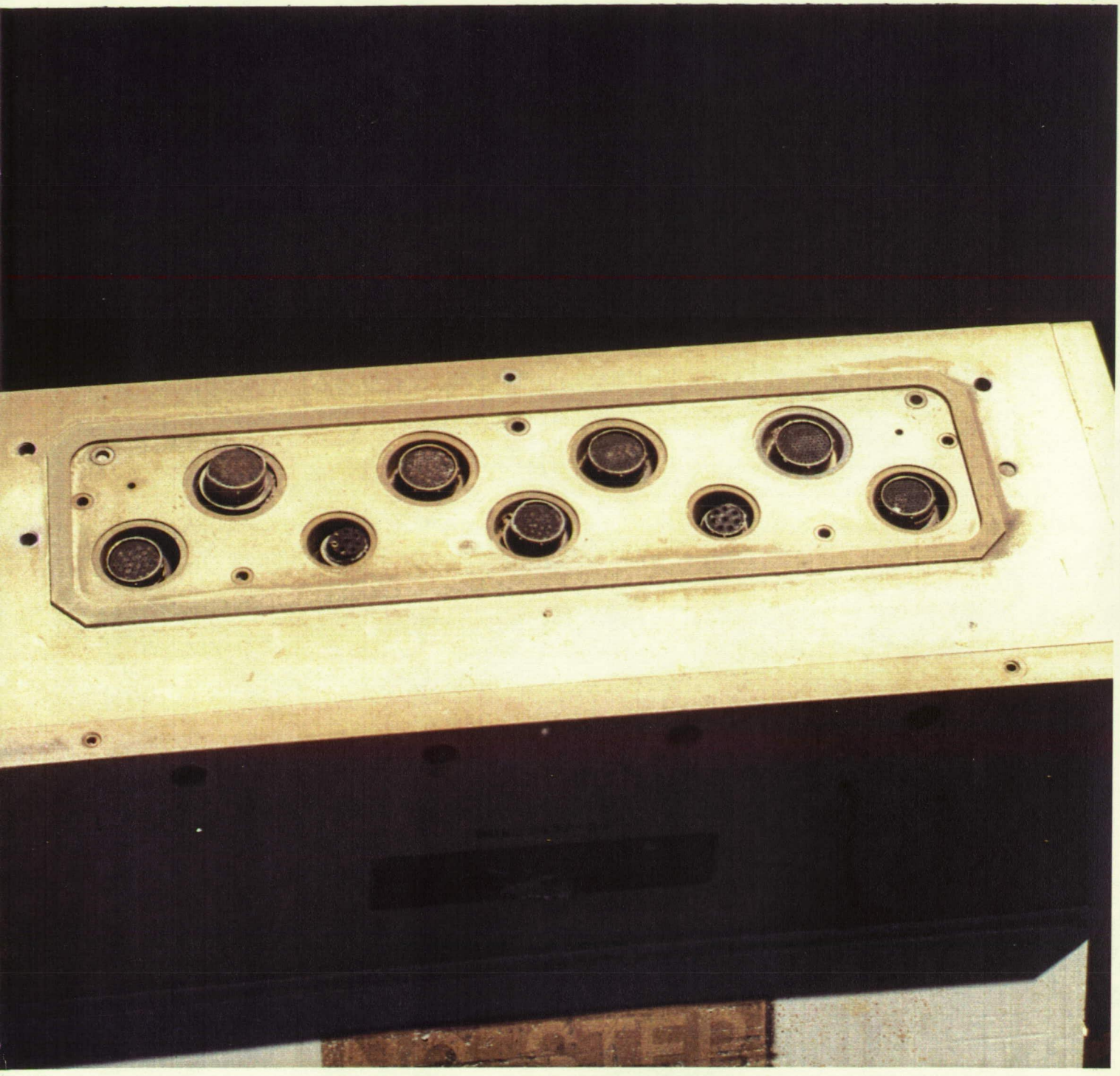

Post launch condition of SRB T-0 umbilical

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7.0 FILM REVIEW AND PROBLEM REPORTS

A total of 146 film and video data items, which included 49 videos, 61 16mm films, 31 35mm films, five 70mm films; and seventeen on-orbit still frames, were reviewed starting on launch day.

No Problem Reports or IFA's were generated as a result of the film and video reviews. Post Launch Anomalies observed in the reviews were presented to the Mission Management Team, Shuttle managers, and vehicle systems engineers. These anomalies are listed in Section 11.

7.1 LAUNCH FILM AND VIDEO SUMMARY

No major vehicle damage or lost flight hardware was observed that would have affected the mission.

One hour into cryo load (T-4:57:54 through T-4:56:36) ten to fifteen drips with vapor trails fell from the aft part of the LH2 ET/ORB umbilical (LH2 recirculation line interface) and appeared to originate from the area of the ice/frost formation along this interface (OTV 009, 063). There was no evidence of a blowing leak, nor did the drips appear for a consistent, frequent, or extended duration. The drips fell below the field of view before completely vaporizing and behaved like liquid air rather than hydrogen. Since that area had just chilled down due to the start of recirculation, the source of the cryogenic drips probably was a small TPS void or defect that had cryopumped locally for a short period of time. No more cryogenic drips occurred for the remainder of cryoload, stable replenish, and flight pressurization. Helium purge vapors and ice build-up on the LH2 umbilical had been typical. There were no unusual vapors or cryogenic drips during liftoff.

SSME gimbal profile appeared normal. Free burning hydrogen was blown under the body flap by southerly winds (OTV 051, 063, 070, 071). Numerous flashes and discolorations, possibly caused by contaminants, occurred in the SSME #2 Mach diamond during ignition (OTV 070, E-2). Orange streaks, typically caused by debris, were visible on the edge of the SSME #1 plume (E-3, 19, 20). Numerous orange flashes occurred in the SSME plume during ascent (E-207, 212, 223).

The closeout blanket around SSME #2 was pulled loose or torn along the outer perimeter at the 11 o'clock position. The separation was approximately 10 inches in length and occurred during SSME ignition (E-24).

SSME ignition acoustics/vibration caused ice to fall from the LO2 and LH2 ET/ORB umbilicals. One piece hit the umbilical cavity sill and was deflected outward (E-25). No tile damage was visible. Two pieces of ice from the LO2 feedline upper bellows and one piece from the LO2 feedline support bracket at station 1377 fell aft without impacting Orbiter tiles (E-5, 25). SSME ignition acoustics/vibration caused the loss of tile surface coating material from one location on the base heat shield near SSME #2, two locations on the base heat shield near SSME #3 (E-23), two locations near the LH OMS nozzle (E-19, 24), six locations near the RH OMS nozzle, and one place from the body flap +Z side (E-17).

The Orbiter T-0 umbilicals disconnected and retracted properly. The liquid oxygen leak in the LO2 TSM had no effect on disconnect and retraction of the carrier plate (OTV 049, 054). Separation of the GUCP from the External Tank was nominal. The GH2 vent arm retracted and latched properly. There was no excessive slack in the static retract lanyard. (OTV 004, OTV 013, E-31, 33, 41, 42, 50)

Film items E-11 and 28 confirmed a stud hang-up on HDP #7. The stud did not begin to drop into the holddown post until the aft skirt passed the doghouse blast cover. The stud rocked slightly from side to side after clearing the aft skirt stud hole. The stud pulled loose EPON shim material, three small pieces adjacent to the stud hole, from the aft skirt foot. No ordnance fragments fell from the HDP #7 DCS/stud hole. Closure of the doghouse blast cover was not affected by the stud hang-up.

Three ordnance fragments fell from the HDP #2 DCS/stud hole shortly after liftoff (E-8). One dark, thin object, possibly a frangible nut web or piece of firing cable, fell between the doghouse blast cover and the HDP #8 shoe (E-14). The new optimized frangible links were installed in the SRB DCS's for this mission.

Numerous particles were ejected out of the SRB exhaust holes after T-0. Many film and video items recorded various amounts of flying debris on and around the pad after the vehicle cleared the tower. This debris is SRB throat plug material and shredded sound suppression water troughs, which is an expected occurrence.

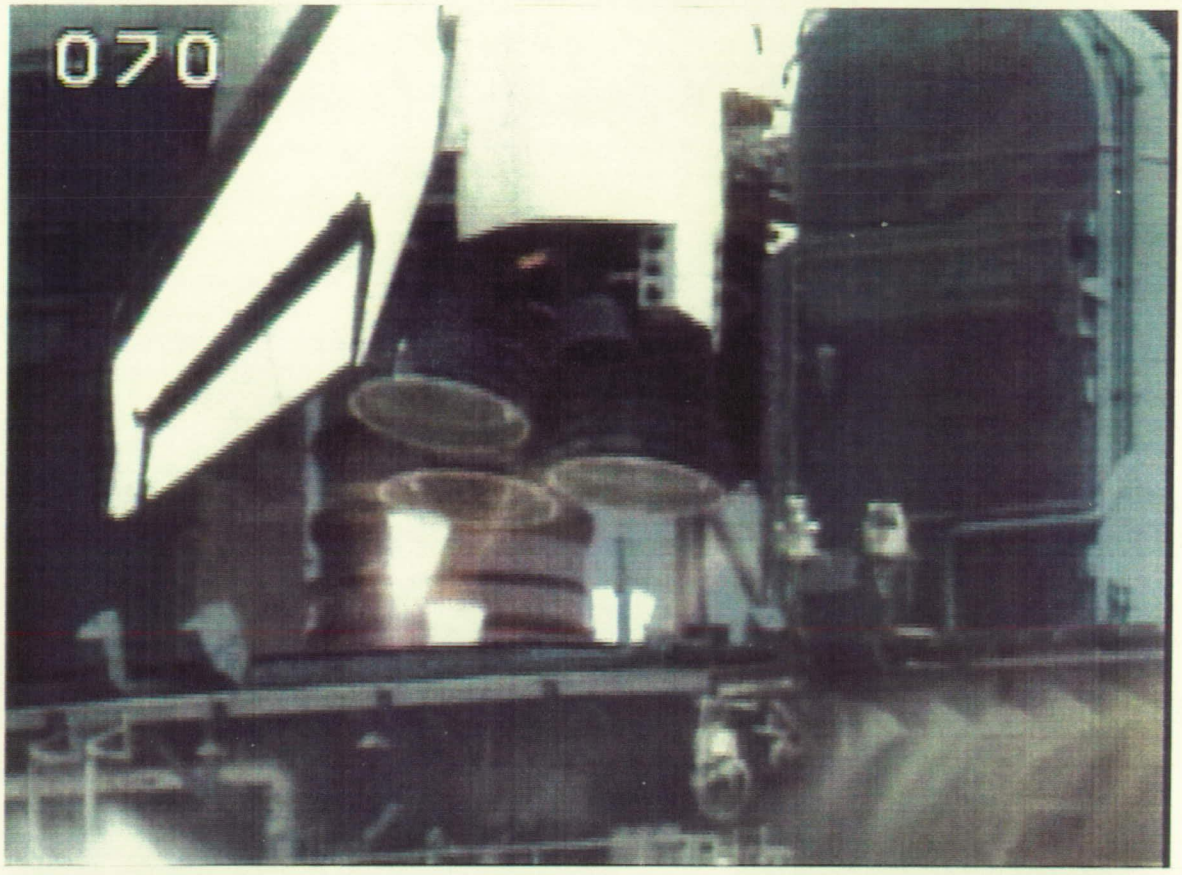
The MLP-1 deck southwest rainbird did not activate at T-0. No water was visible exiting the rainbird as the vehicle cleared the tower and SRB plume obscured the rainbird. (E-4, 31, 60)

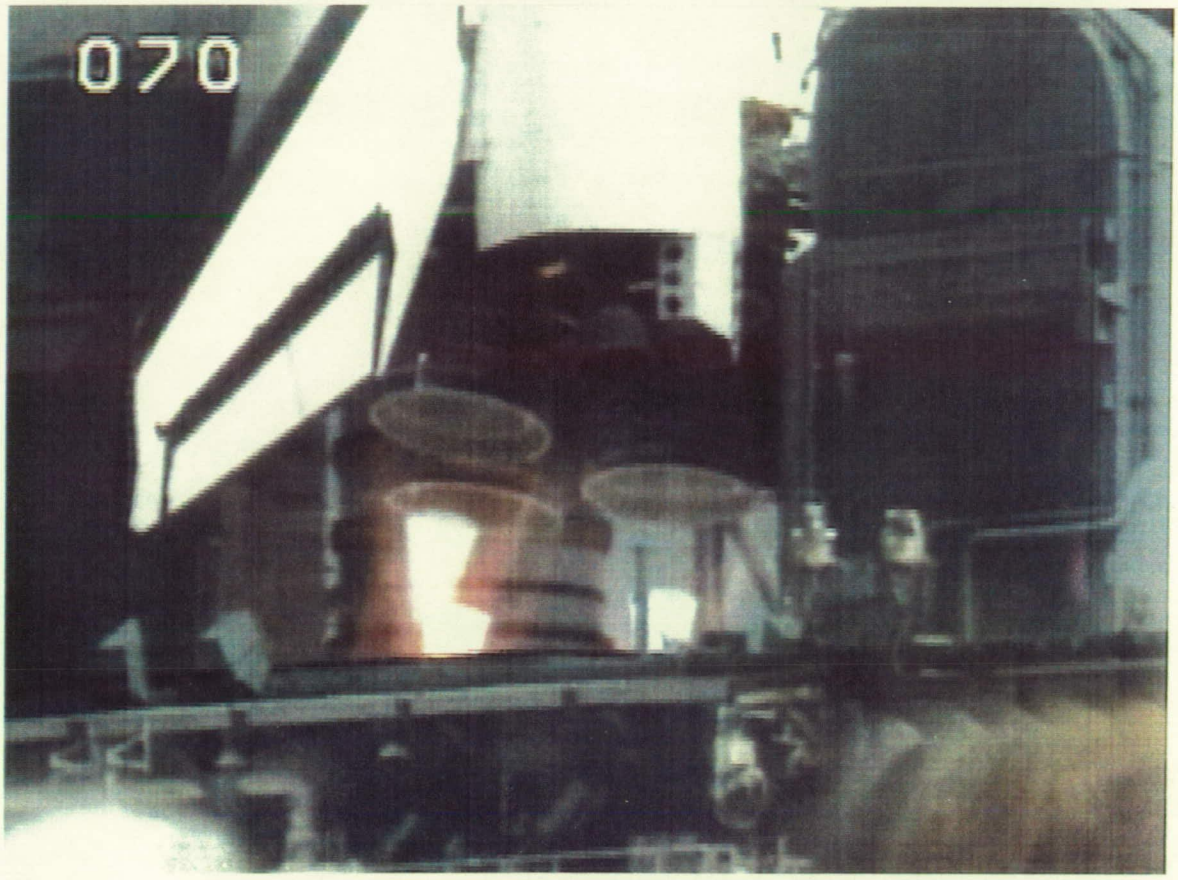
A white object fell from the aft end of the Orbiter at T+42.844 seconds MET in film item E-220, frames 4276 through 4342. The object, believed to be a section of the SSME closeout blanket, appeared to originate near SSME #2, crossed the base heat shield, passed behind the LH aft RCS stinger, reappeared near the LH OMS nozzle, moved aft along SSME #1, moved around the

SSME #1 nozzle, and finally fell aft of the Orbiter before being lost against the SRB plume. (Film items E-208, 213, 218, 222; video items ET-204, 208, 212, TV-4A)

Light-colored particles, believed to be pieces of aft skirt instafoam or small chunks of SRB propellant, fell out of the SRB plume during ascent (TV-4A).

ET aft dome charring, plume recirculation, and SRB separation appeared normal.





Initial SSME ignition and gimbal profile appeared nominal (top). Numerous flashes and discolorations, possibly caused by contaminants, occurred in the SSME #2 Mach diamond during ignition (bottom).

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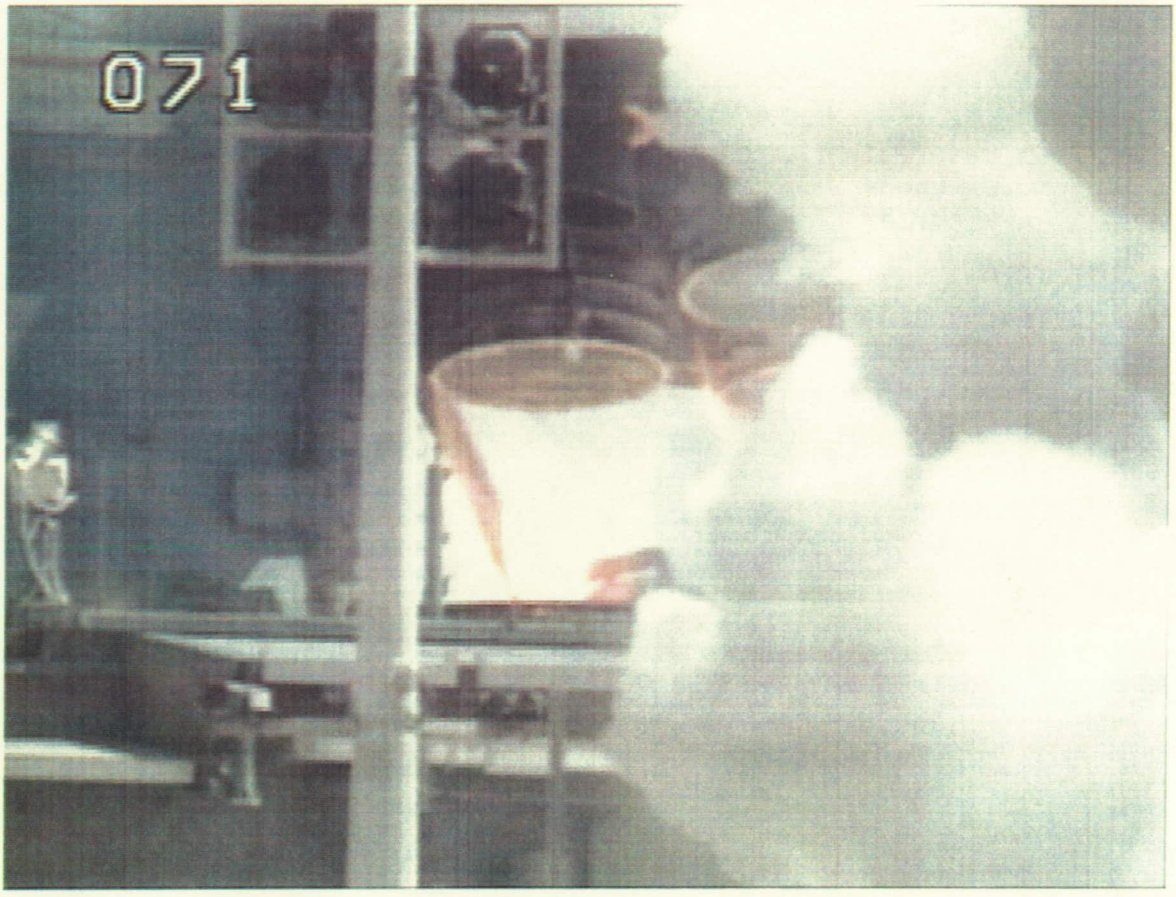

Orange streaks, typically caused by debris such as pieces of aft RCS paper covers, were visible on the edge of the SSME #1 plume

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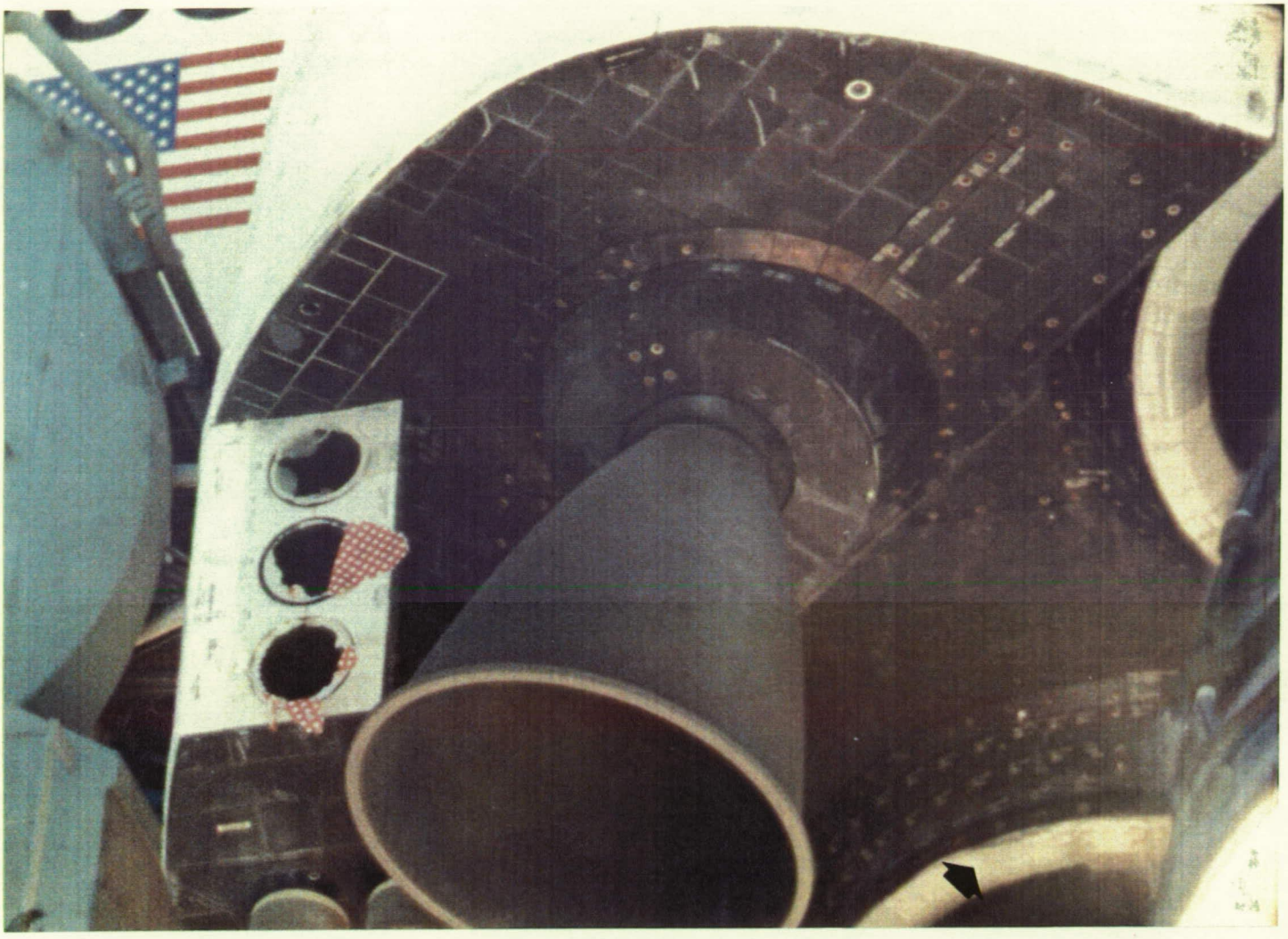

The SSME #2 closeout blanket was pulled loose or torn along the outer perimeter at the 11 o'clock position during SSME ignition. The separation was approximately 10 inches in length and occurred near the blanket splice. Post landing inspection revealed the outer layer of that ten inch section was missing.

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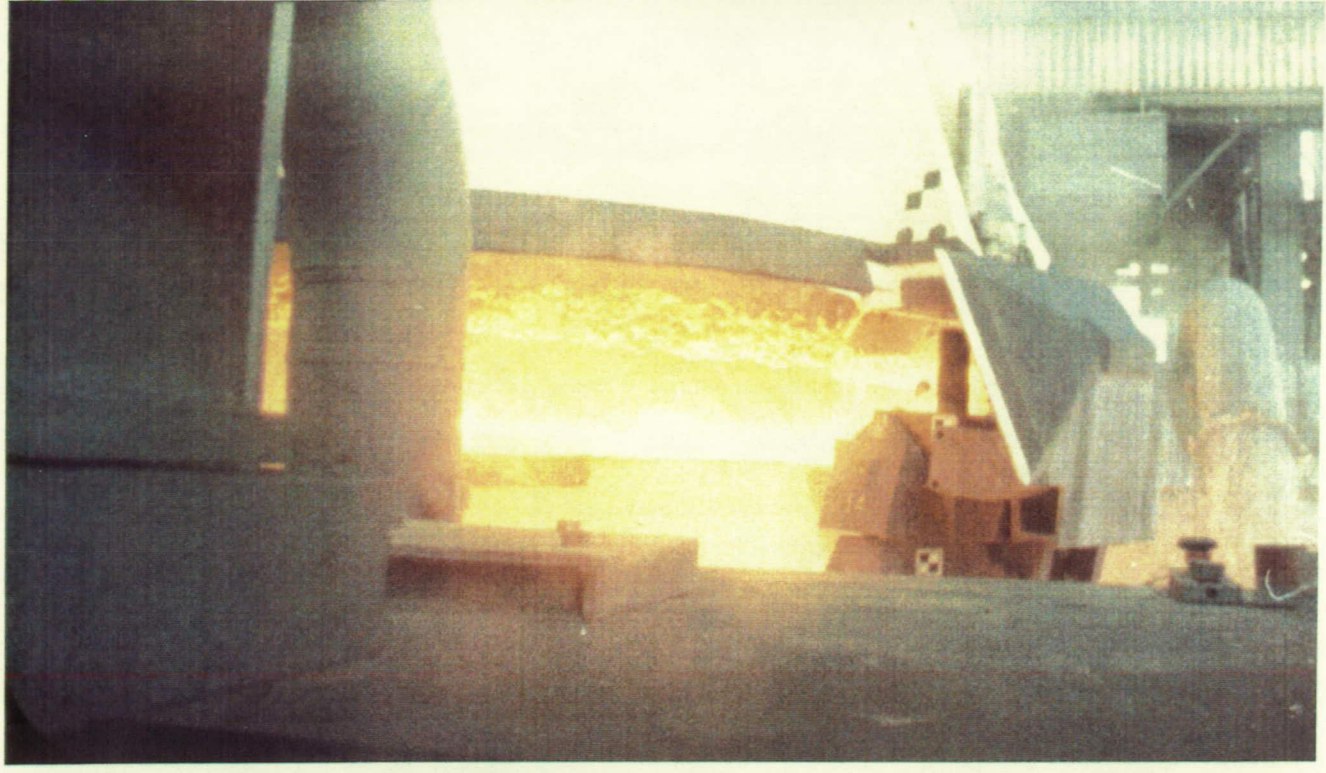
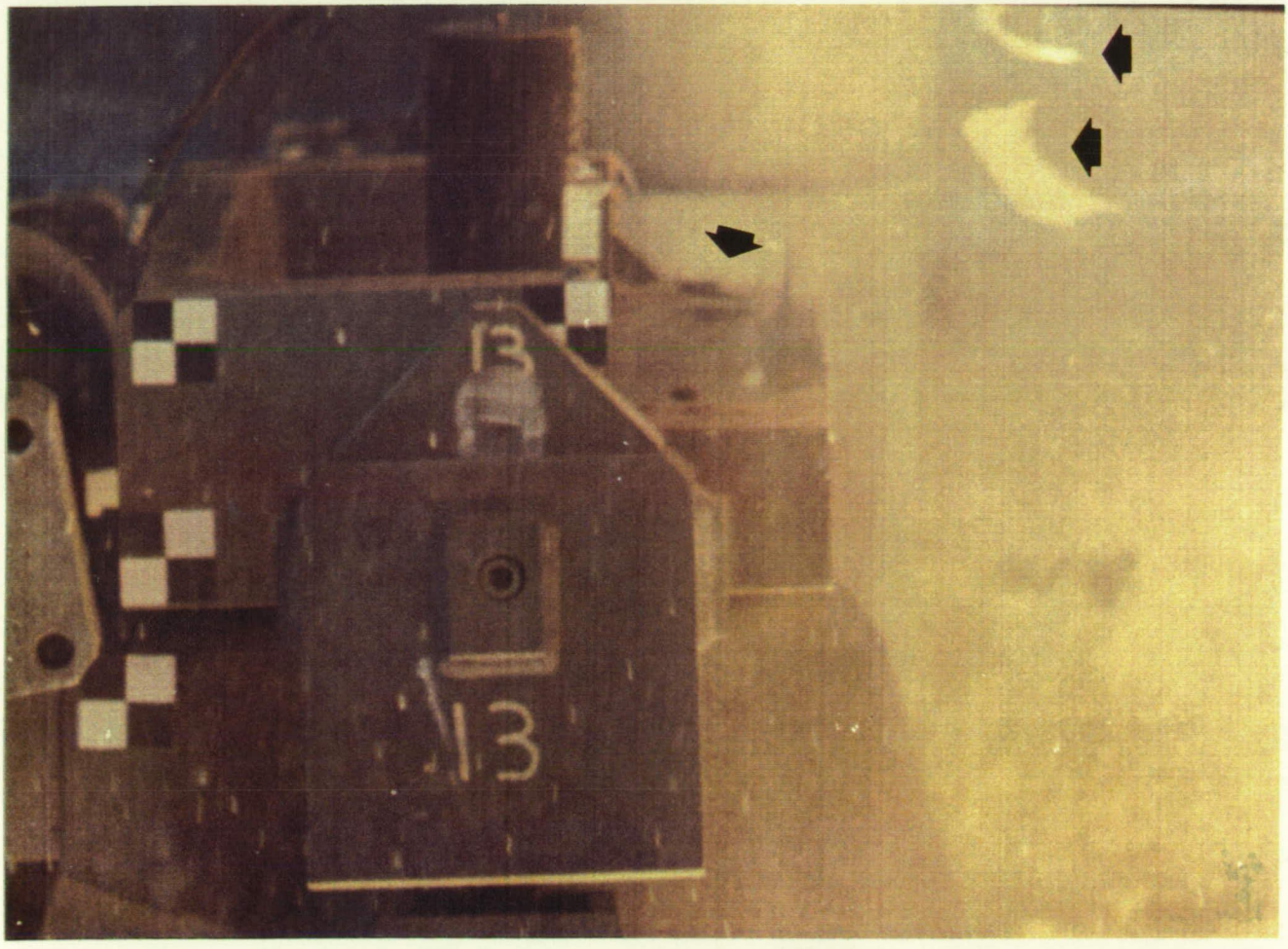




A stud hang-up occurred on holddown post #7. The stud pulled loose EPON shim material (arrows), three pieces adjacent to the stud hole, from the aft skirt foot. No ordnance fragments fell from the HDP #7 DCS/stud hole.

ORIGINAL PAGE
COLOR PHOTOGRAPH

A white object fell from the aft end of the Orbiter at T+43 seconds MET. The object, believed to be a section of the SSME closeout blanket, appeared to originate between SSME #1 and #2, moved passed the SSME #1 nozzle (arrow), and fell aft of the vehicle.

ORIGINAL PAGE
COLOR PHOTOGRAPH

7.2 ON-ORBIT FILM AND VIDEO SUMMARY

Review/analysis of on-orbit photography included seventeen 70mm still frames of the ET after separation from the Orbiter (DTO-312) and one 16mm motion picture film of payload deployment.

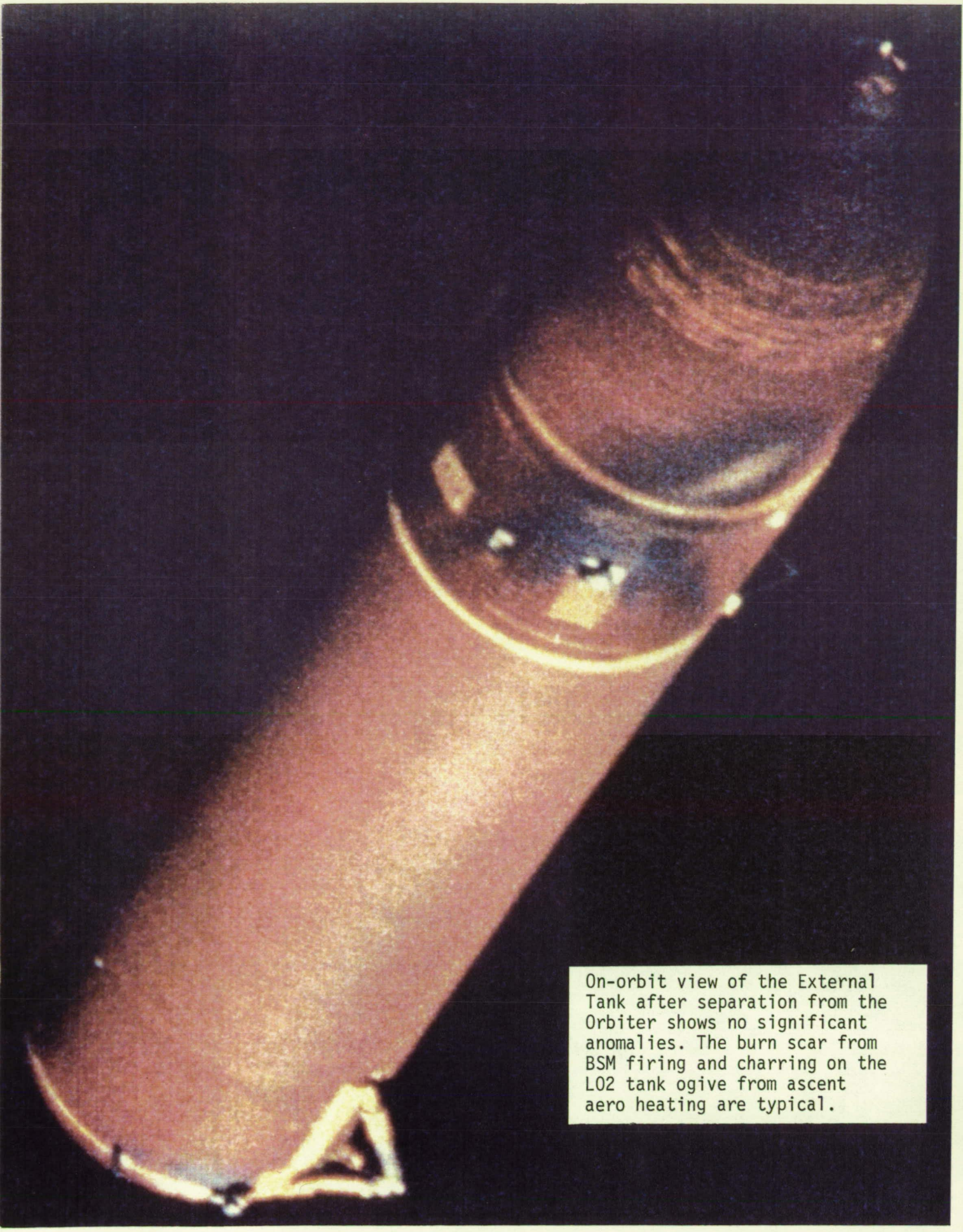
No major vehicle damage or lost flight hardware was observed that would have affected the mission.

Two light spots on the LH2 tank-to-intertank flange appeared to be possible divots 6-8 inches in diameter in the TPS closeout. The divots were located in the -Y-Z quadrant below the intertank access door and were not a debris threat to the Orbiter. Bright spots on the LH2 tank acreage outboard of the -Y longeron and near the aft hard point were sanded repair areas.

There were no apparent anomalies on LO2 tank, LH2 tank, and aft dome TPS acreage. The BSM burn scars were typical. The nosecone, intertank access door, GH2 umbilical carrier plate, -Y ET/SRB fitting, and RSS antennae were in nominal configuration.

Detail on the +Y and +Z sides of the External Tank was not discernible due to shadows and underexposure of the film.

Shortly after TDRSS/IUS deployment, a light-colored, curved object with a smooth concave side and rough, textured convex side appeared to originate from the aft end of the Orbiter and drifted over the left wing. Similar floating objects have been observed previously on STS-35 and STS-41. The most likely candidate for the object is solid, or frozen, oxygen dislodged from one of the SSME nozzles. The Main Propulsion System contains over 3800 pounds of residual oxygen at ET separation. Of this total, 270 pounds is vented through the SSME seal drain lines at the nozzle exit plane, 3400 pounds is dumped through the SSME nozzles, and the remainder is vented through the LO2 T-0 umbilical fill and drain valve. At a temperature below -360 degrees F, the oxygen solidifies and accumulates on the SSME nozzles. Photographs from previous missions show this ice adhering to the exit plane of the SSME nozzles. Transmitting a vibration through the Orbiter structure, such as the deployment of a payload, or melting from the sun, causes the ice to be dislodged from the SSME nozzles.



On-orbit view of the External Tank after separation from the Orbiter shows no significant anomalies. The burn scar from BSM firing and charring on the LO2 tank ogive from ascent aero heating are typical.

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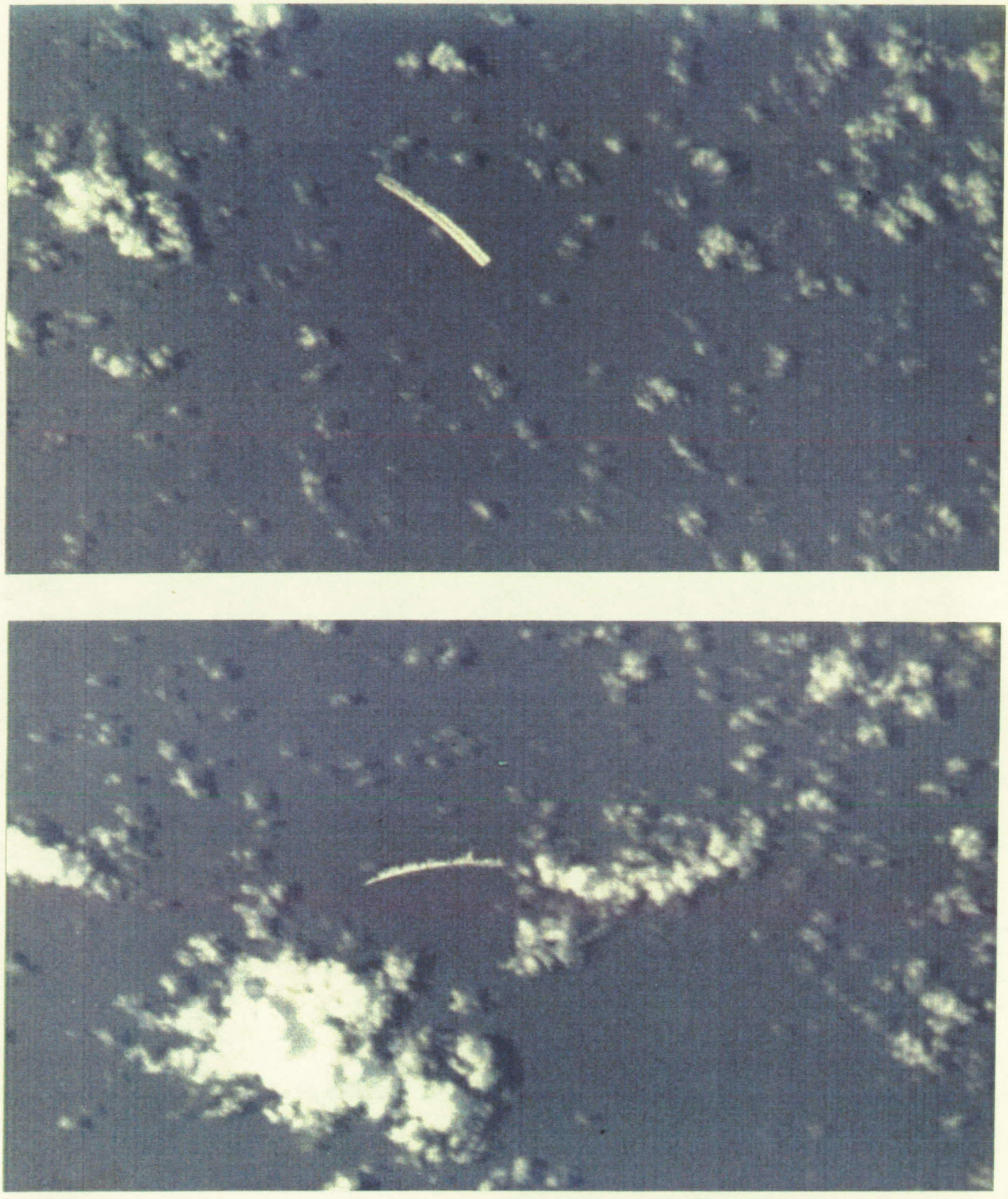


Shortly after TRDSS/IUS deployment, a light-colored, curved object with a smooth concave side and rough, textured convex side appeared to originate from the aft end of the Orbiter. Similar floating objects have been observed previously on STS-35 and STS-41. The most likely candidate for the object is frozen oxygen that had adhered to one of the SSME nozzles during the MPS dump.

ORIGINAL PAGE
COLOR PHOTOGRAPH

7.3 LANDING FILM AND VIDEO SUMMARY

Orbiter performance in the Heading Alignment Circle (HAC) and final approach was nominal.

Five dark objects, possibly small pieces of black tile material, fell from the LH aft side of the Orbiter while crossing the runway threshold.

Both main landing gear touched down almost simultaneously with the right side slightly ahead of the left gear. Touchdown of the nose gear was smooth. There were no vehicle anomalies or unusual control surface deflections during the rollout.

No significant tile damage was visible on the Orbiter lower surface except for one site on the right side of the Orbiter nose below the forward RCS module. Frayed pieces of SSME closeout blankets flapped in the airflow from portions of all three SSME collars during the rollout.

8.0 SRB POST FLIGHT/RETRIEVAL DEBRIS ASSESSMENT

Both Solid Rocket Boosters were inspected for debris damage and debris sources at CCAFS Hangar AF on 4 August 1991 from 0945 to 1130 hours. In general, the SRB's appeared to be in good condition.

8.1 RH SOLID ROCKET BOOSTER DEBRIS INSPECTION

The RH frustum was missing no TPS but had 46 MSA-2 debonds over fasteners. There was minor localized blistering of the Hypalon paint (Figure 9). The BSM covers were locked in the open position, but the two LH covers were bent upward by parachute riser entanglement.

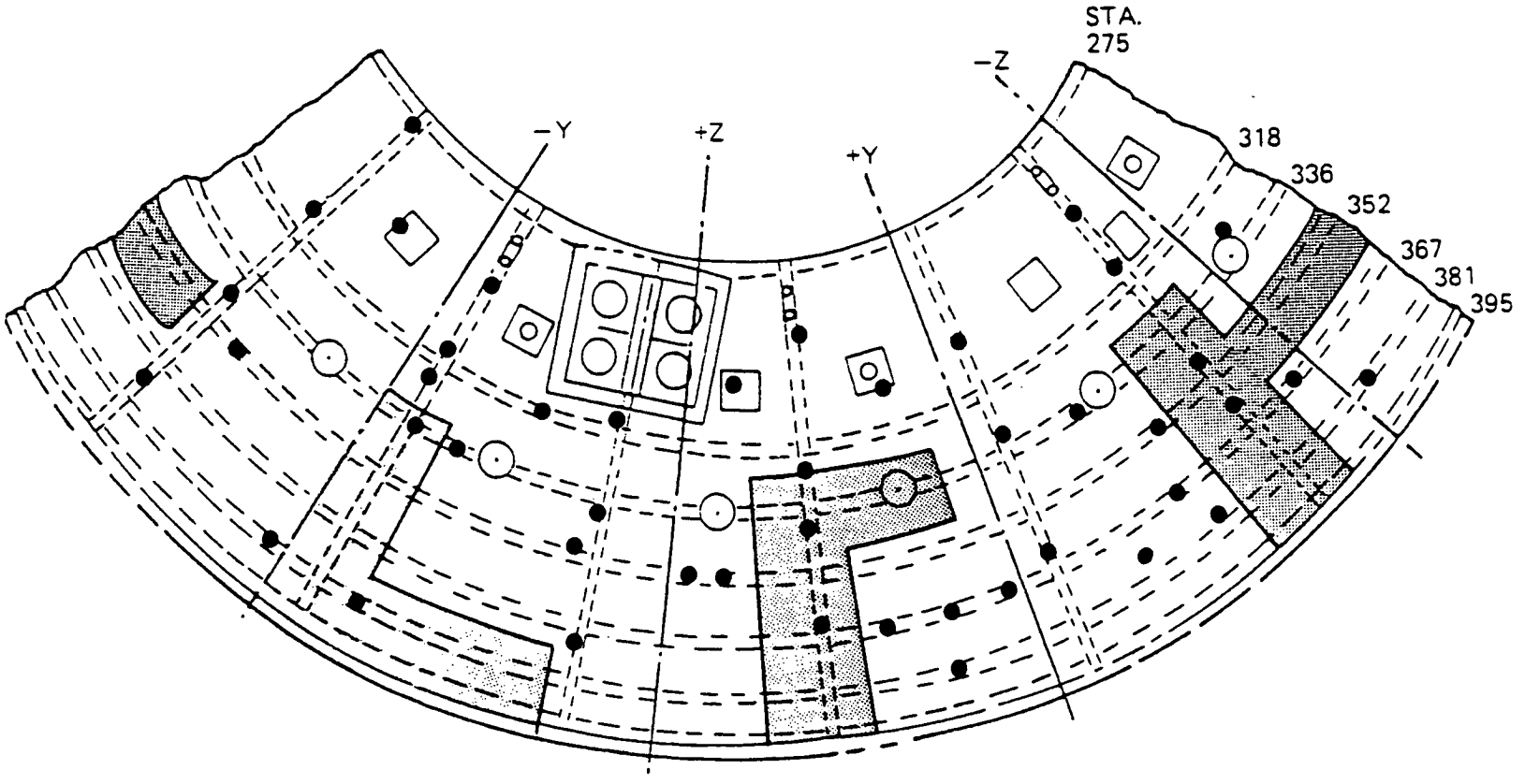
The RH forward skirt exhibited no debonds or missing TPS. The phenolic plates on both RSS antennae were intact. The forward separation bolt and electrical cables appeared to have separated cleanly. No pins were missing from the frustum severance ring. Minor blistering of the Hypalon paint occurred forward of the ET/SRB attach point (Figure 10).

The Field Joint Protection System (FJPS) closeouts were generally in good condition. Small K5NA cracks, approximately 3/4 inch diameter, occurred on the center field joint pin band trunnion closeout at the 150 degree location and on the forward field joint near the Kevlar strap clip at the 312 degree location. Minor trailing edge damage to the FJPS and the GEI cork runs were attributed to debris resulting from severance of the nozzle extension. Hypalon paint was missing from the aft field joint cork at the 0 degree location. The area was 4 feet long and covered the width of the cork closeout.

Separation of the aft ET/SRB struts appeared normal. The ET/SRB aft struts, ETA ring, and IEA appeared undamaged. All three aft booster stiffener rings sustained water impact damage at approximately 110-120 degrees. The aft booster stiffener ring splice plate closeouts were intact and no K5NA material was missing. The aft dome factory joint weather seal debonded approximately 4 inches circumferentially at the 270 degree location (aft side).

The phenolic material on the kick ring delaminated at only a few locations. Three K5NA protective domes were lost from bolt heads on the aft side of the phenolic kick ring near HDP #3 prior to water impact. The aft skirt acreage TPS was in good condition (Figure 11). K5NA was missing from all of the aft BSM nozzles. Three of four HDP Debris Containment System (DCS) plungers were seated properly. The HDP #2 plunger was obstructed by a frangible nut half. This was the second flight utilizing the optimized link. All of the HDP #3 EPON shim material was intact. Most of the HDP #4 EPON shim material was lost at water impact except for a 5"x2.5" area, which showed a charred substrate.

FIGURE 9. RIGHT SRB FRUSTUM



MISSING TPS

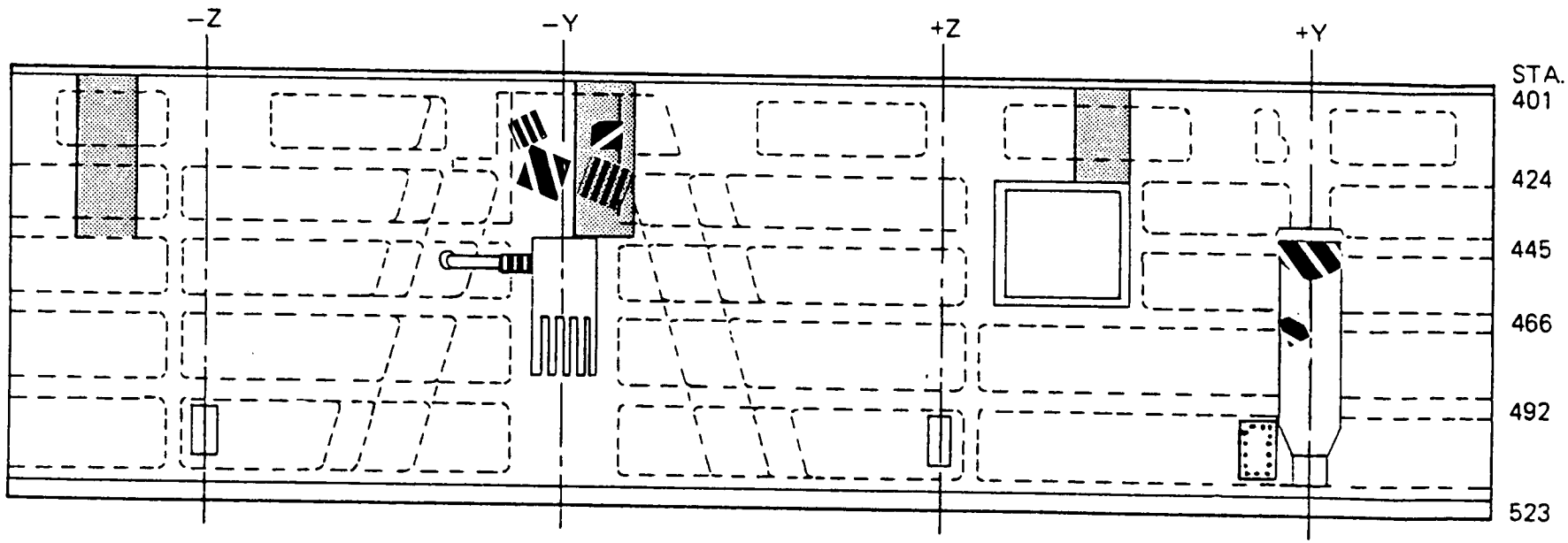
NONE

DEBONDS

● 46

EGG/V-326

FIGURE 10. RIGHT SRB FWD SKIRT



TPS MISSING

NONE

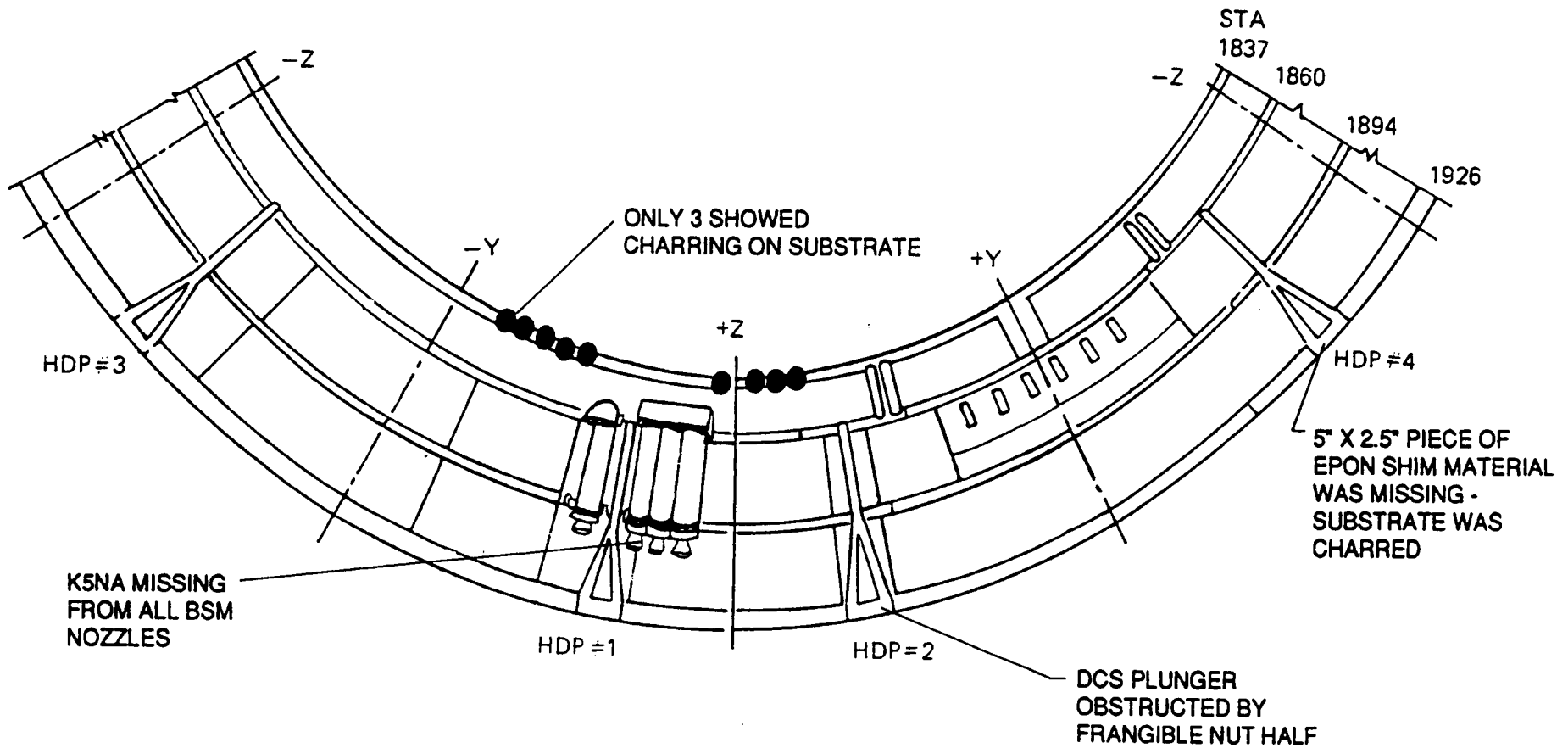
DEBONDS

NONE

BLISTERING

CHARRING

FIGURE 11. RIGHT SRB AFT SKIRT EXTERIOR TPS

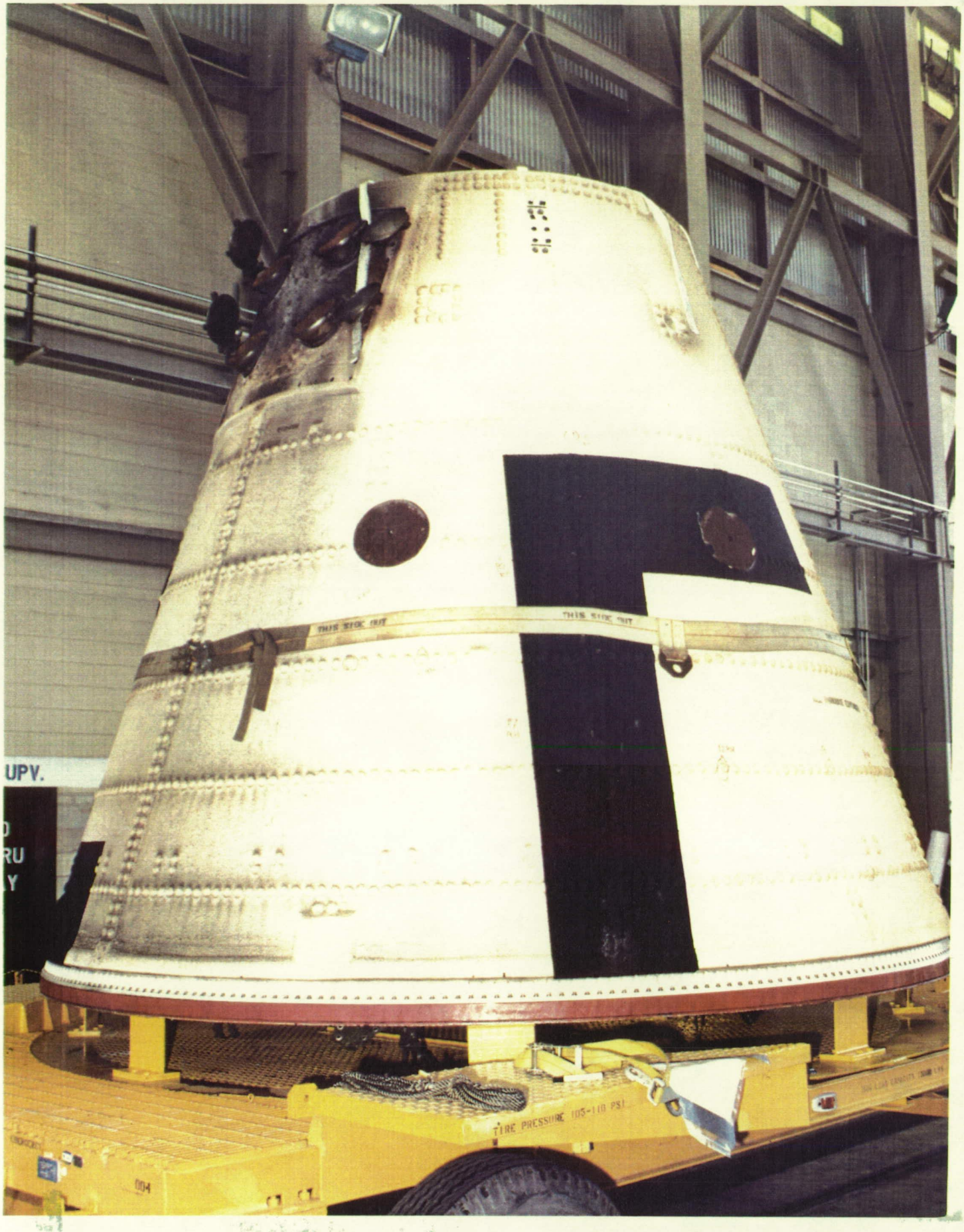


● MISSING K5NA PROTECTIVE DOMES

NOTES:

TYPICAL CHARRING & BLISTERING OF HYPALON PAINT OCCURRED ON AFT SKIRT ACREAGE

EGG/V 326C



The RH frustum was missing no TPS but had 46 MSA-2 debonds over fasteners.

C-2

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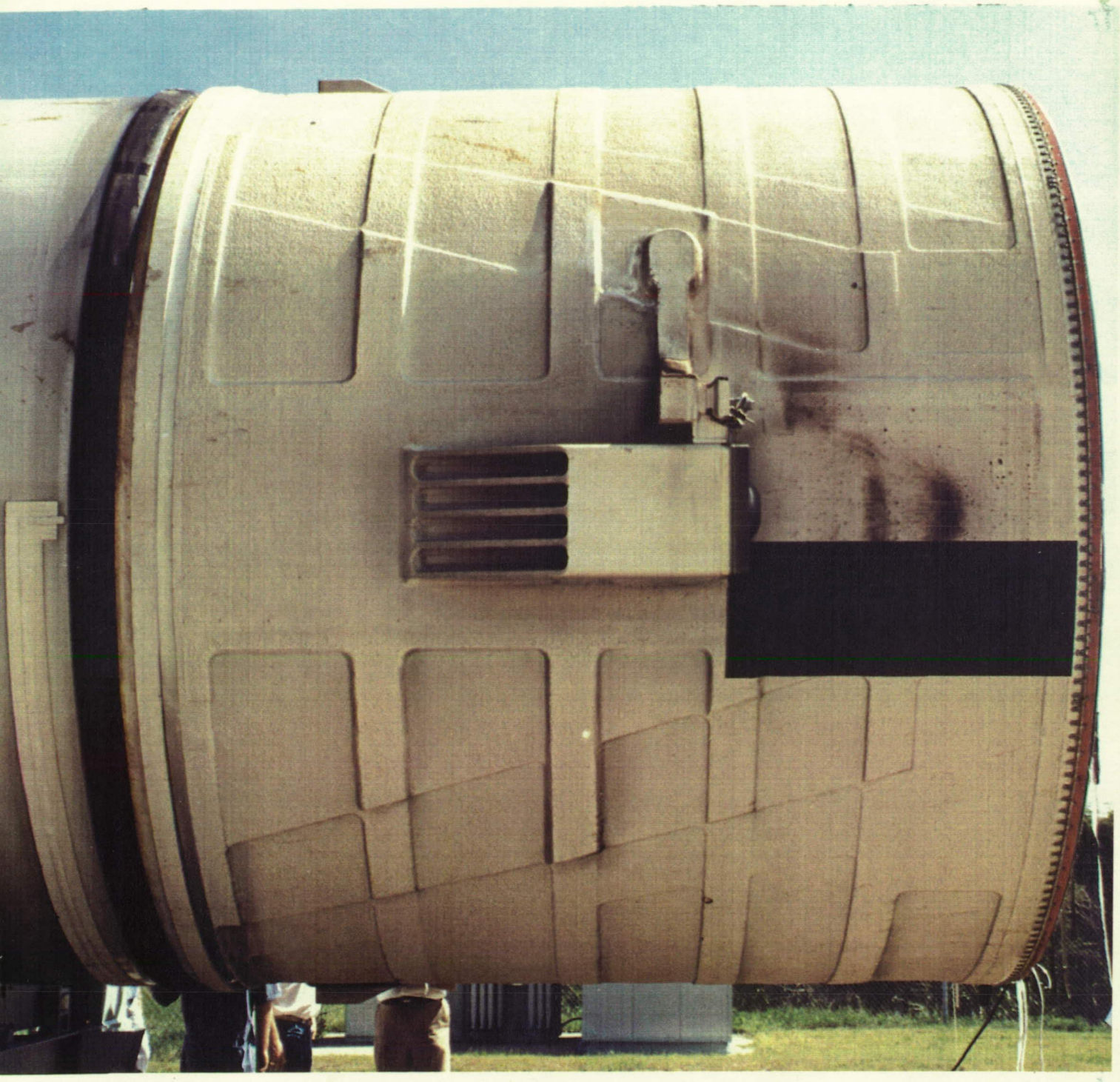

The RH forward skirt exhibited no debonds or missing TPS. Both RSS antenna phenolic plates were intact. Minor blistering of the Hypalon paint occurred forward of the ET/SRB attach point.

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The Field Joint Protection System closeouts were generally in good condition. Hypalon paint was missing from the aft field joint cork at the 0 degree location. The area was 4 feet long and covered the width of the cork closeout.

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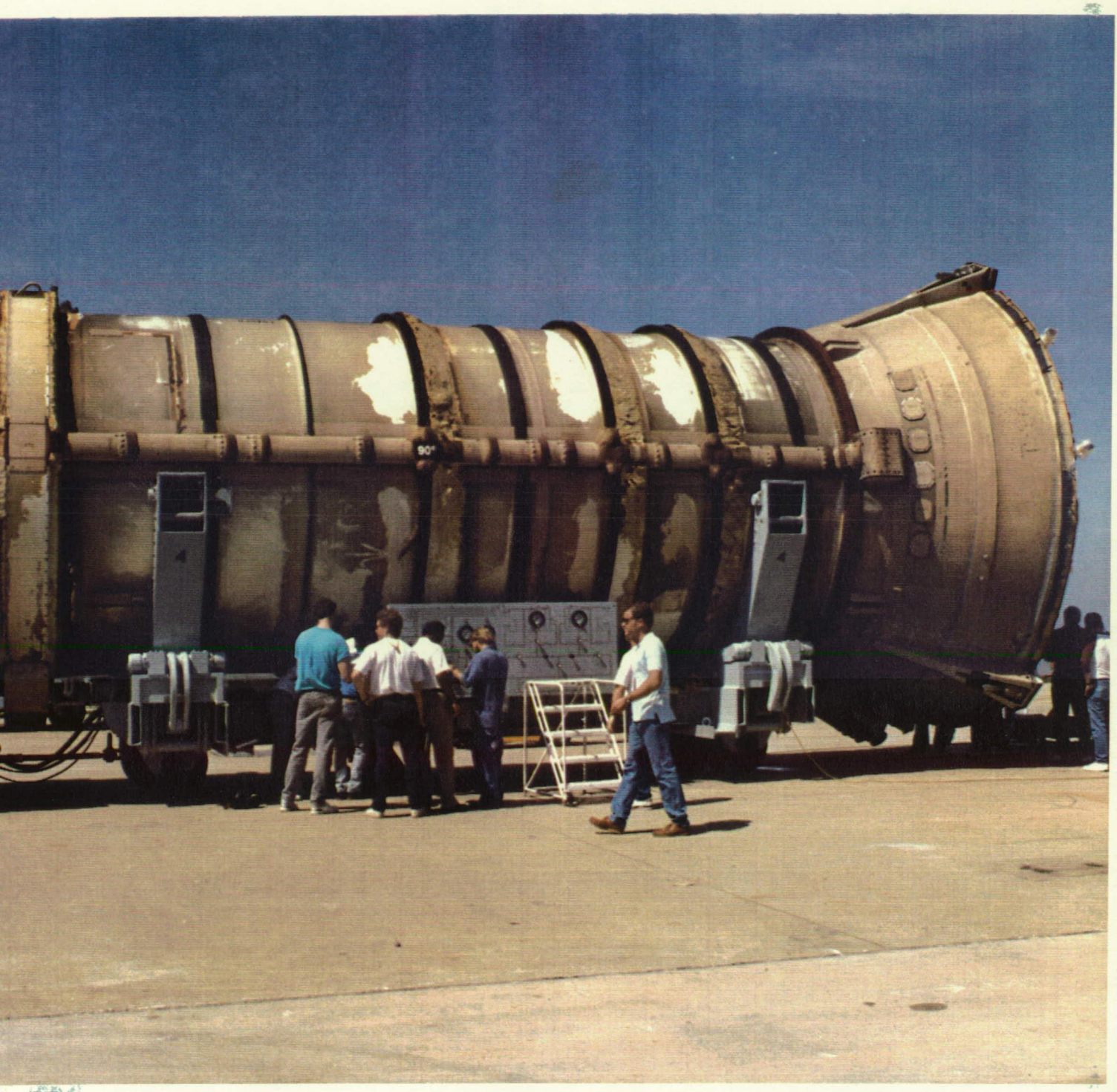

Post flight condition of the RH aft booster. The aft skirt acreage TPS was in good condition.

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COLOR PHOTOGRAPH

All of the HDP #3 EPON shim material was intact. Shim material should remain attached to the aft skirt during flight.

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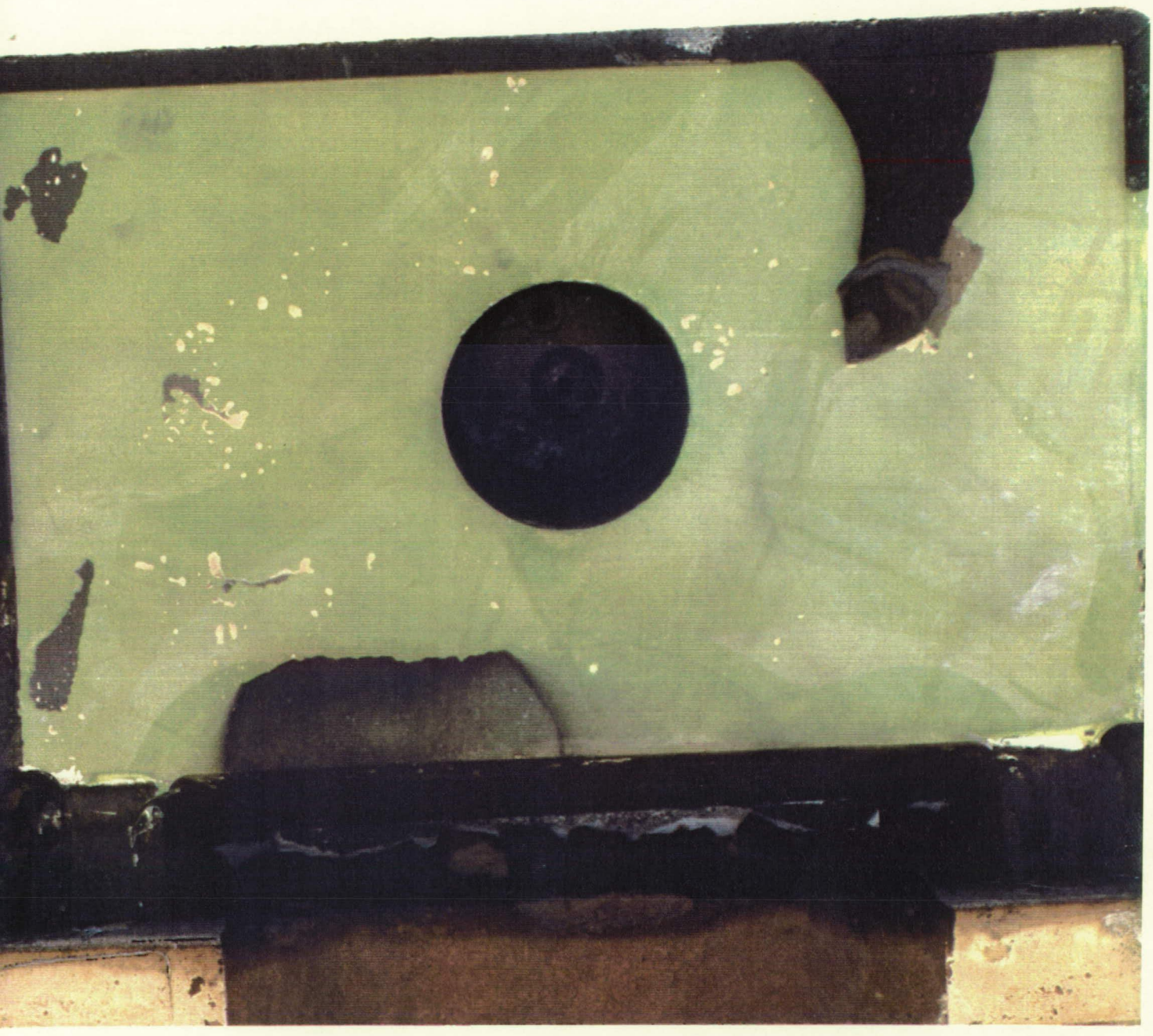
COLOR PHOTOGRAPH



Most of the HDP #4 EPON shim material was lost at water impact except for a 5"x2.5" area, which showed a charred substrate.

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The HDP #2 DCS plunger was obstructed by a frangible nut half

ORIGINAL PAGE
COLOR PHOTOGRAPH

8.2 LH SOLID ROCKET BOOSTER DEBRIS INSPECTION

The LH frustum exhibited no missing TPS but had 38 MSA-2 debonds over fasteners (Figure 12). Minor blistering of the Hypalon paint occurred at three locations. All BSM covers were locked in the fully opened position.

The LH forward skirt exhibited no debonds. MSA-2, 2.5"x1" in size, was missing from an area one foot forward of the skirt clevis and one foot outboard of the +Z RSS antenna (aft of the flight door). The phenolic plates on both RSS antennae were intact. At least one layer of the phenolic plate on the +Z antenna was delaminated. The forward separation bolt and electrical cables appeared to have separated cleanly. No pins were missing from the frustum severance ring. Minor blistering of the Hypalon paint occurred forward of the ET/SRB attach point (Figure 13).

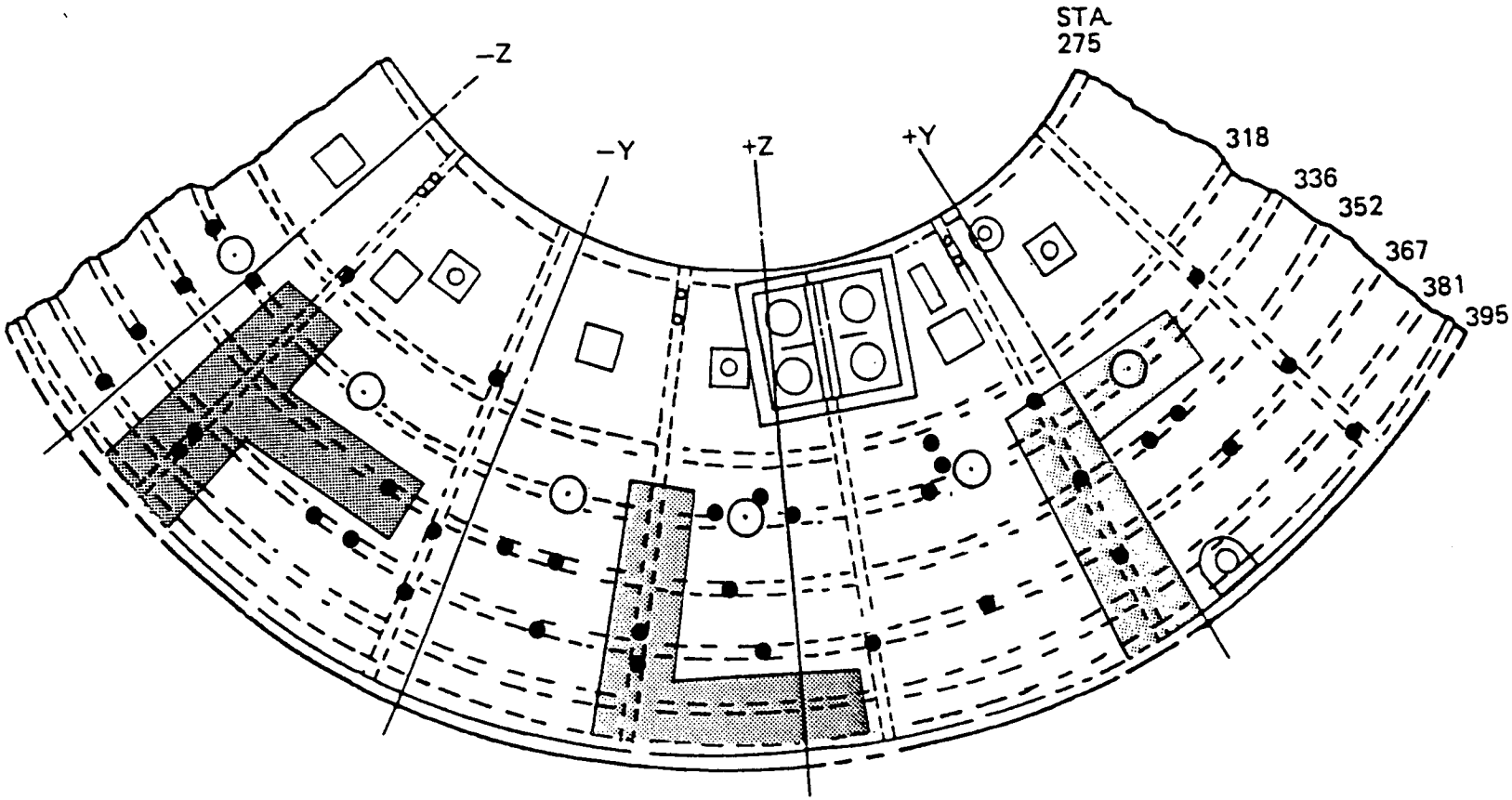
The Field Joint Protection System (FJPS) closeouts were in good condition. Minor trailing edge damage to the FJPS and the GEI cork runs were attributed to debris resulting from severance of the nozzle extension. K5NA was missing from the center field joint closeout at the 150 degree location. The area, measuring 4"x2.5"x3/8" deep, exhibited a clean substrate. The K5NA had failed along a bond line between layers. Hypalon paint was missing from the aft field joint cork at the 0 degree location. The area was three feet long and spanned both forward and aft strips.

Separation of the aft ET/SRB struts appeared normal. The ET/SRB aft struts, ETA ring, IEA, and aft booster stiffener rings appeared undamaged. The aft booster stiffener ring splice plate closeouts were intact and no K5NA material was missing.

The phenolic material on the kick ring delaminated at several locations. One K5NA protective dome was lost from a bolt head on the aft side of the phenolic kick ring near HDP #5 prior to water impact. The aft skirt acreage TPS was in good condition (Figure 14). K5NA was missing from all aft BSM nozzles.

All four HDP Debris Containment System (DCS) plungers were seated. This was the second flight utilizing the optimized link. The HDP #7 aft skirt bolt hole was broached along the hole edge closest to the centerline of the SRB. EPON shim material adjacent to the broached edge was missing.

FIGURE 12. LEFT SRB FRUSTUM



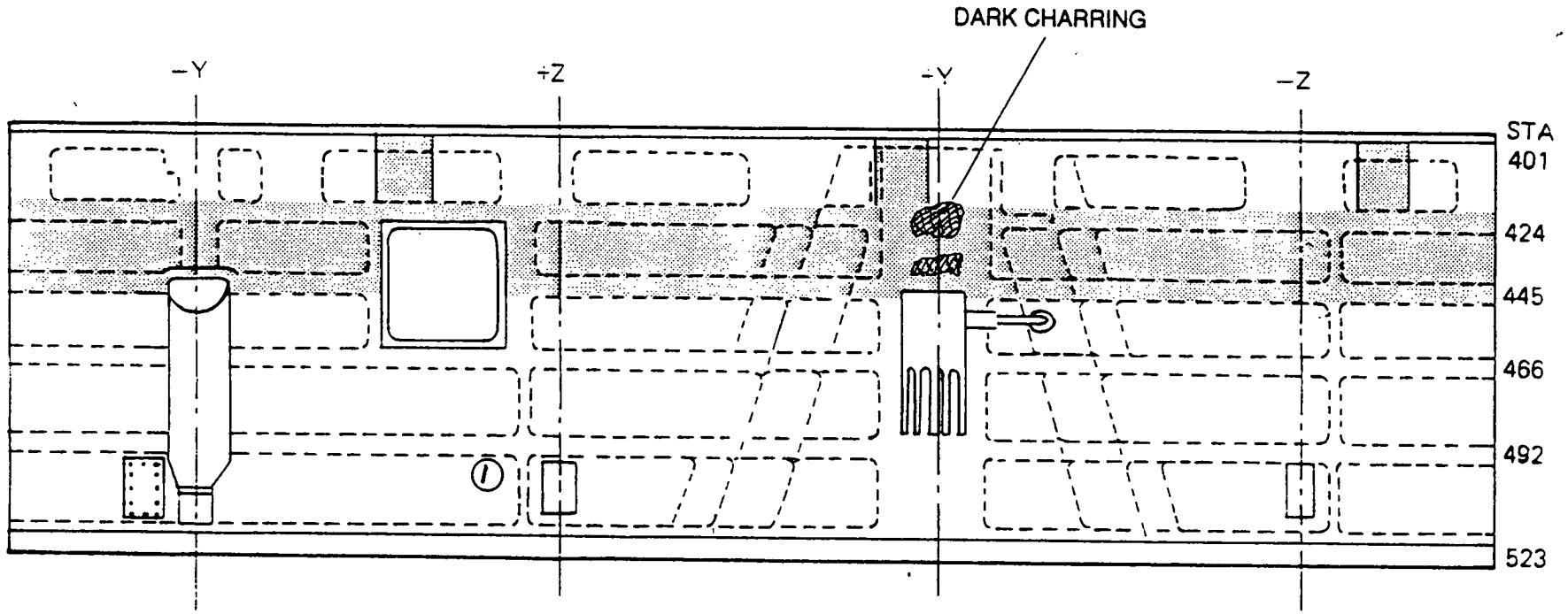
MISSING TPS

NONE

DEBONDS

● 38

FIGURE 13.



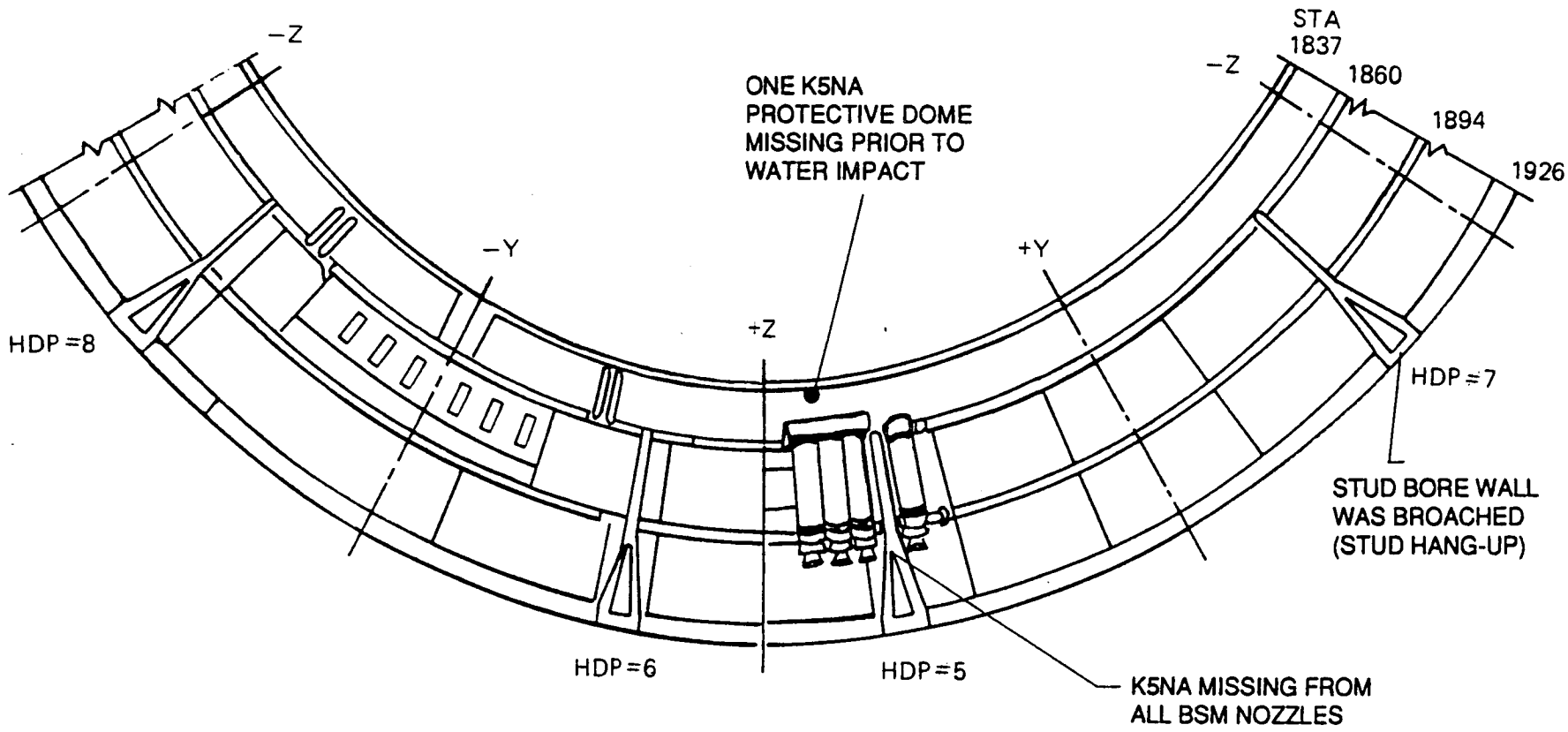
TPS MISSING	DEBONDS
1. 2.5" X 1" PIECE	NONE

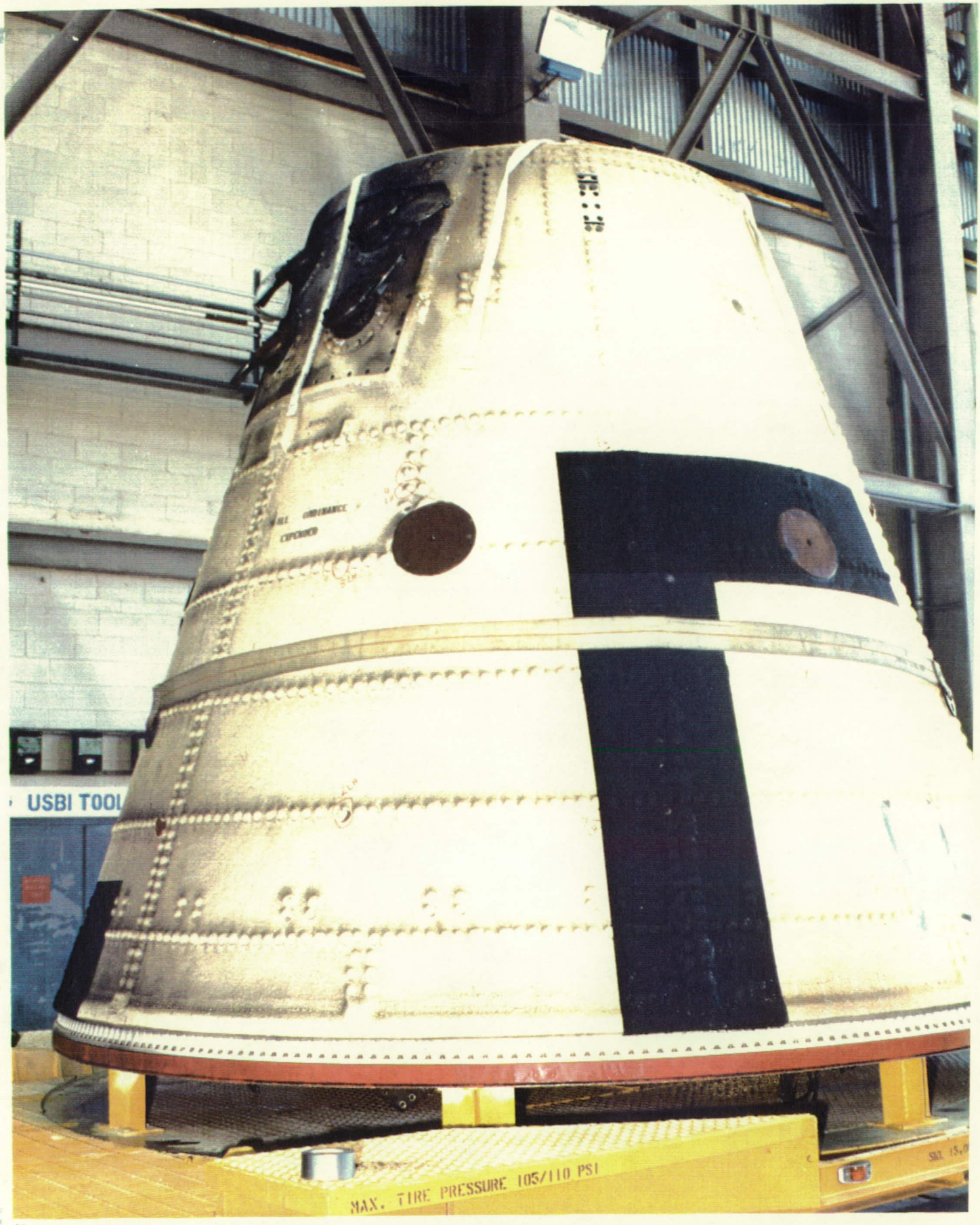
NOTES:

1 LAYER OF THE PHENOLIC PLATE ON THE +Z RSS ANTENNA WAS DELAMINATED

LEFT SRB AFT SKIRT EXTERIOR TPS

FIGURE 14.





The LH frustum was missing no TPS but had 38 MSA-2 debonds over fasteners

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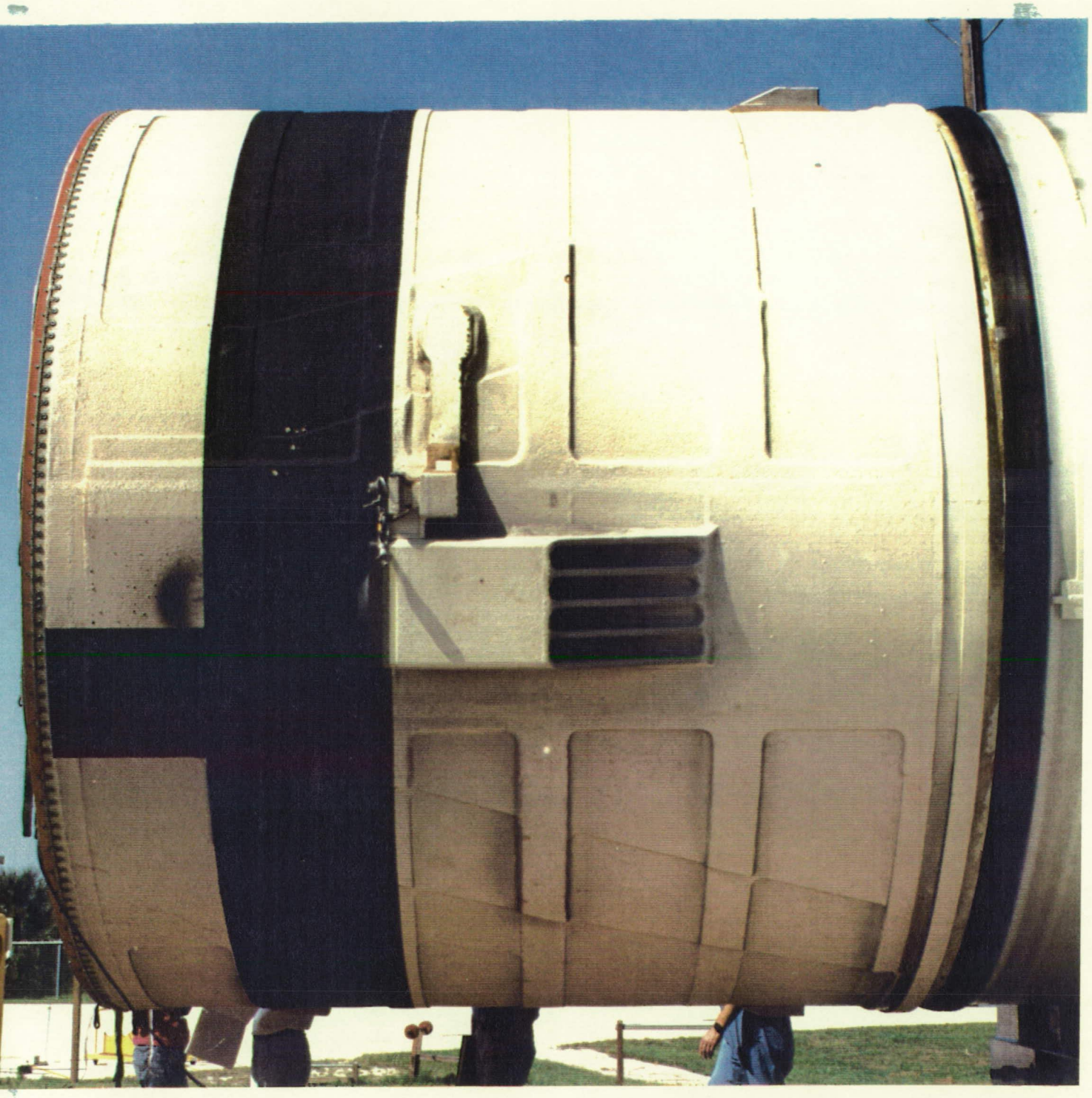

The left forward skirt exhibited no MSA-2 debonds. Minor blistering of Hypalon paint occurred forward of the ET/SRB attach point.

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The acreage MSA-2 on the LH forward skirt was generally in good condition except for a 2.5"x1" divot located one foot forward of the clevis and one foot outboard of the +Z RSS antenna (aft of the flight door).

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Post flight condition of the LH aft booster/aft skirt
The aft skirt acreage TPS was generally in good condition

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COLOR PHOTOGRAPH

The aft booster stiffener ring splice plate closeouts were intact and no K5NA material was missing prior to water impact.

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COLOR PHOTOGRAPH

The HDP #7 aft skirt bolt hole was broached along the hole edge closest to the centerline of the SRB. EPON shim material adjacent to the broached edge was missing.

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COLOR PHOTOGRAPH

8.3 RECOVERED SRB DISASSEMBLY FINDINGS

Post flight disassembly of the Debris Containment System (DCS) housings revealed an overall system retention of 92 percent and individual holddown post retention percentages as listed:

HDP #	Overall %	% of Nut without 2 large halves	% of Ordnance
1	98	99+	92
2	31	34	27
3	99	99+	92
4	99	99+	94
5	99	99+	95
6	99	99+	92
7	99	99+	90*
8	99	99+	92

* A portion of booster cartridge was welded to the frangible nut half. The weight of this piece was included with the frangible nut.

The new 'optimized' frangible links had been attached to the DCS plungers for this mission. The minimum allowable retention per NSTS-07700 is 90 percent.

SRB Post Launch Anomalies are listed in Section 11.

9.0 ORBITER POST LANDING DEBRIS ASSESSMENT

A detailed post landing inspection of OV-104 (Atlantis) was conducted on August 11 and 12, 1991, at the Kennedy Space Center on Runway 15 and in OPF Bay #2 to identify debris impact damage, and if possible, debris sources. The Orbiter TPS sustained a total of 131 hits, of which 25 had a major dimension of one inch or greater. This total does not include the numerous damage sites on the base heat shield, which were attributed to SSME vibration/acoustics and plume recirculation. The following table breaks down the STS-43 Orbiter debris damage by area:

	Hits > or = 1"	Total Hits
Lower Surface	24	122
Upper Surface	0	2
Right Side	0	2
Left Side	1	5
Right OMS Pod	0	0
Left OMS Pod	0	0
TOTALS	25	131

Runway 15 was inspected by SLF Operations and EG&G personnel on August 10-11, 1991, and potentially damaging debris was removed. The runway condition was determined to be acceptable.

The post landing inspection of Runway 15 was performed approximately one half hour after landing. One piece of flight hardware was found on the runway beneath the LO2 ET/Orbiter umbilical. A metallic U-shaped object, identified as a V072-565471-001 yoke, originated from the LO2 umbilical forward inboard separation bolt head. The yoke measured 2.75" x 1.0" x 0.937". A 6" x 5" piece of tile, missing from the right main landing gear door outboard forward corner, was not found.

The Orbiter lower surface had a total of 122 hits of which 24 had a major dimension of one inch or greater. A comparison of these numbers to statistics from 29 previous missions of similar configuration (excluding missions STS-24, 25, 26, 26R, 27R, and 30R which had damage from known debris sources), indicates both the total number of hits and the hits one inch or larger on the lower surface was greater than average. Figures 15 through 18 show the TPS damage locations for STS-43.

The largest single damage site on the Orbiter lower surface occurred on the RH nose area below the forward RCS module and measured approximately 18" x 1" x 1/8" (spanned 6 tiles). This shallow hit is indicative of damage typically caused by low density material, such as ET SOFI. Post-separation ET photographs taken by the crew (DTO-312) showed only the -Y side of the tank and could not confirm the loss of ET TPS.

FIGURE 15. **STS-43**

DEBRIS DAMAGE LOCATIONS

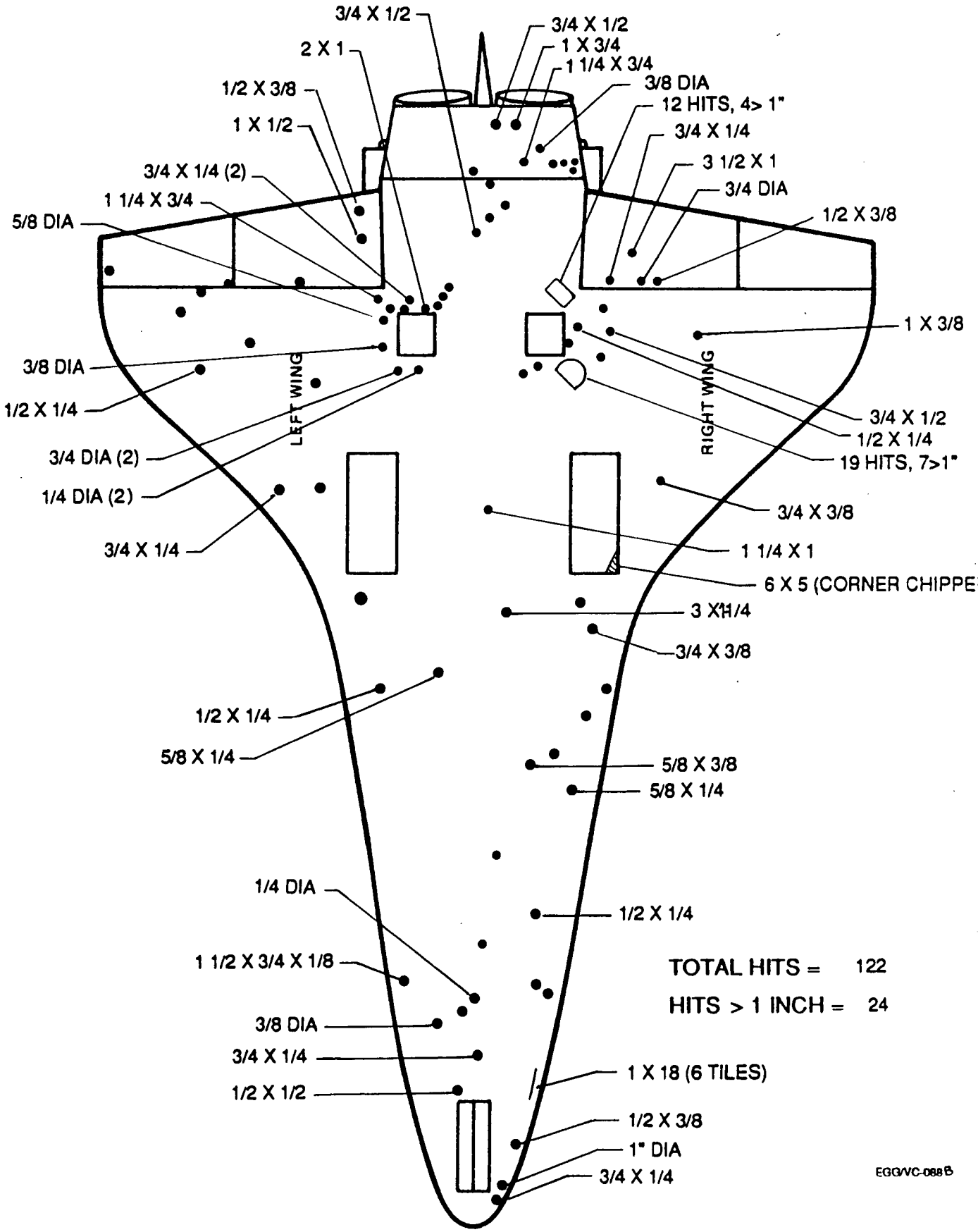
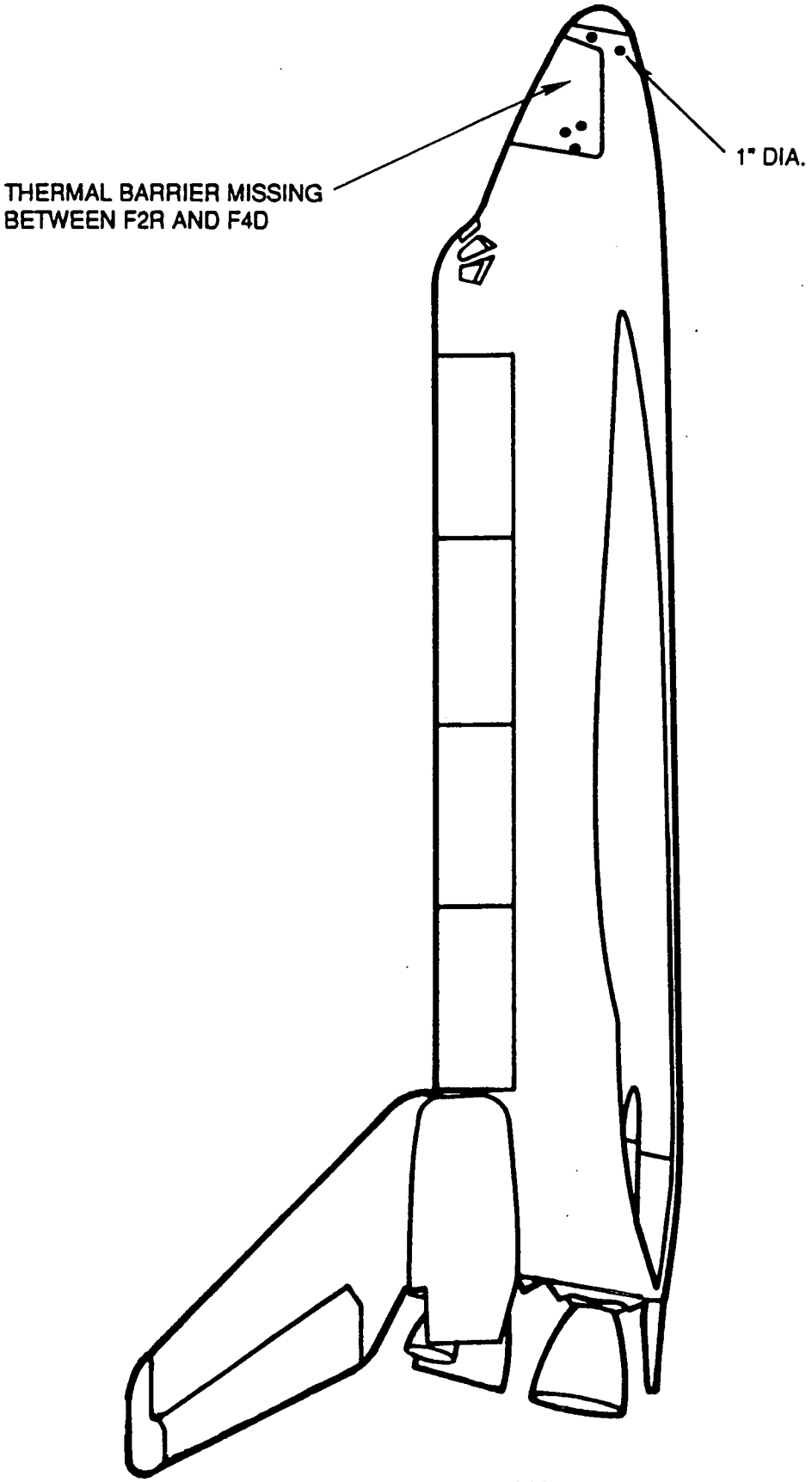


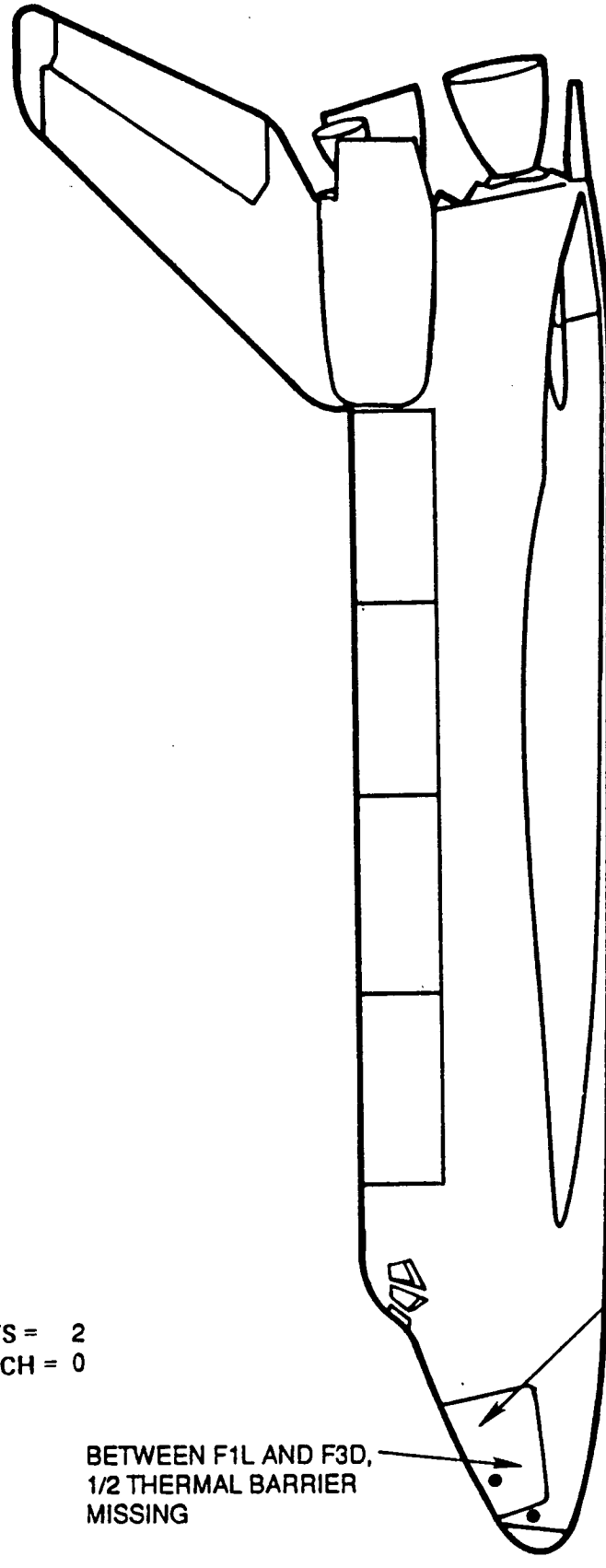
FIGURE 16. STS-43

DEBRIS DAMAGE LOCATIONS



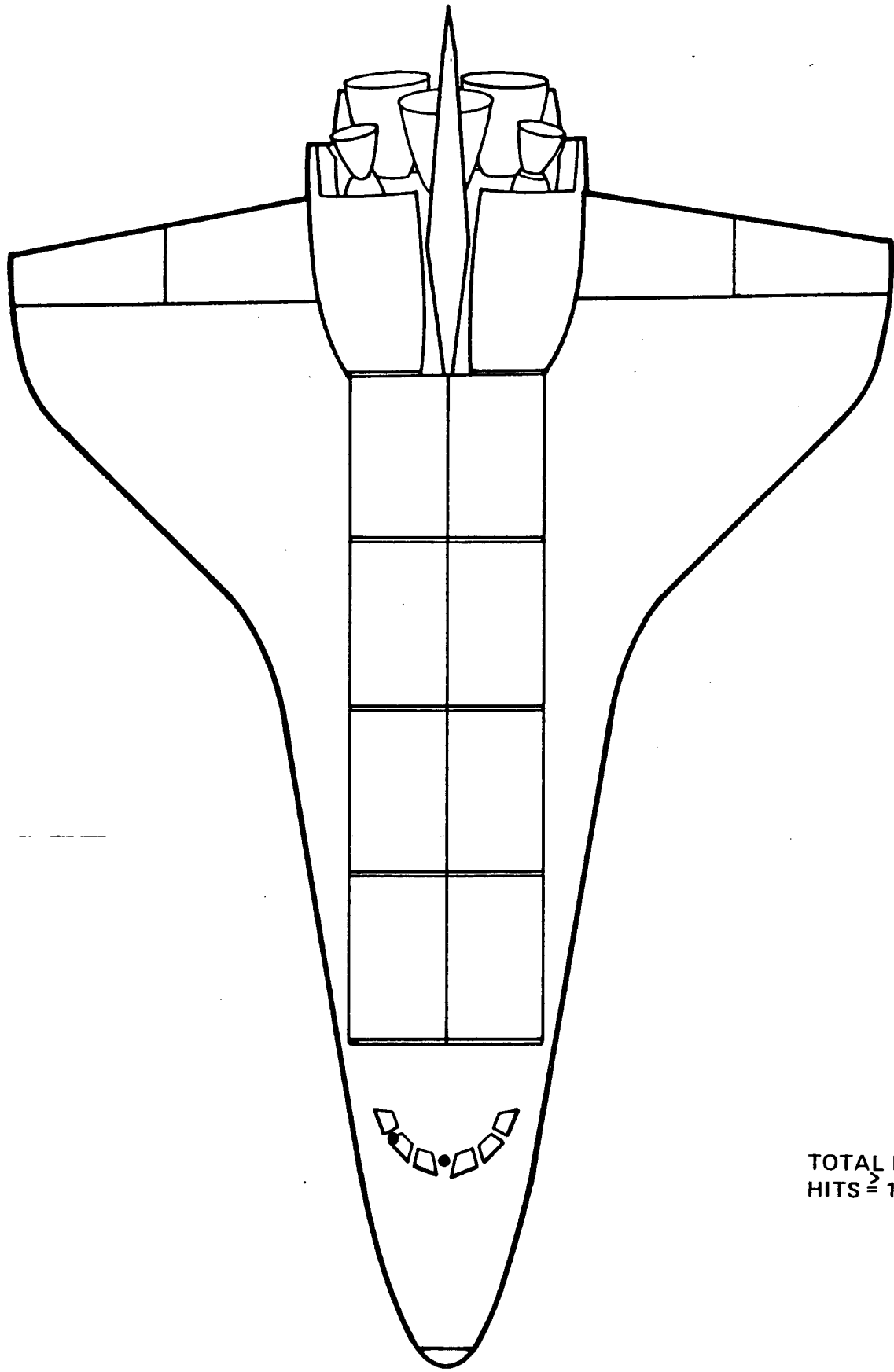
TOTAL HITS =
HITS ≥ 1 INCH =

FIGURE 17. **STS-43**
DEBRIS DAMAGE LOCATIONS



EGG/V-0

FIGURE 18. **STS-43**
DEBRIS DAMAGE LOCATIONS



TOTAL HITS =
HITS ≥ 1 INCH =

EGG

A cluster of 19 hits (with 7 larger than one inch) occurred just forward of the LO2 ET/Orbiter umbilical. Similar clusters of hits have been observed in this area on previous flights and may be attributed to ice from the LO2 feedline bellows or support brackets. A second cluster of 12 hits (with 4 larger than one inch) occurred just aft of the LO2 ET/ORB umbilical cavity and may be attributed to ice from the LO2 ET/ORB umbilical during ET separation and/or damage from purge barrier baggie and ice during ascent.

The ET/ORB separation ordnance device plungers were seated and appeared to have functioned properly. No ordnance fragments were missing other than the yoke from the LO2 umbilical forward inboard separation bolt. The lightning protection contacts on both ET/Orbiter umbilicals were intact. No lightning protection contacts from the ET half of the umbilical were present. There appeared to be no significant heat intrusion past the thermal barriers around the ET doors.

No TPS damage was attributed to material from the wheels, tires, or brakes. The main landing gear tires were considered to be in good condition for a landing on the KSC concrete runway. All main gear tires exhibited some minor material loss with most of the loss occurring on the LH inboard tire.

Damage to the base heat shield tiles was average. The outer layer of SSME #3 closeout blanket was peeled back along a 12 inch length at 10:00 o'clock. Minor fraying occurred along a 12 inch length at 9:00 o'clock. The outer layer of the SSME #2 closeout blanket was frayed along a 12 inch length at the 8 o'clock location. SSME #1 closeout blanket was missing numerous layers of material from 4:00 to 7:00 o'clock (approximately 40 inches in length) and may have been the white object observed in films falling aft of the Orbiter 43 seconds after launch.

The overall condition of the TPS on the OMS pods was good.

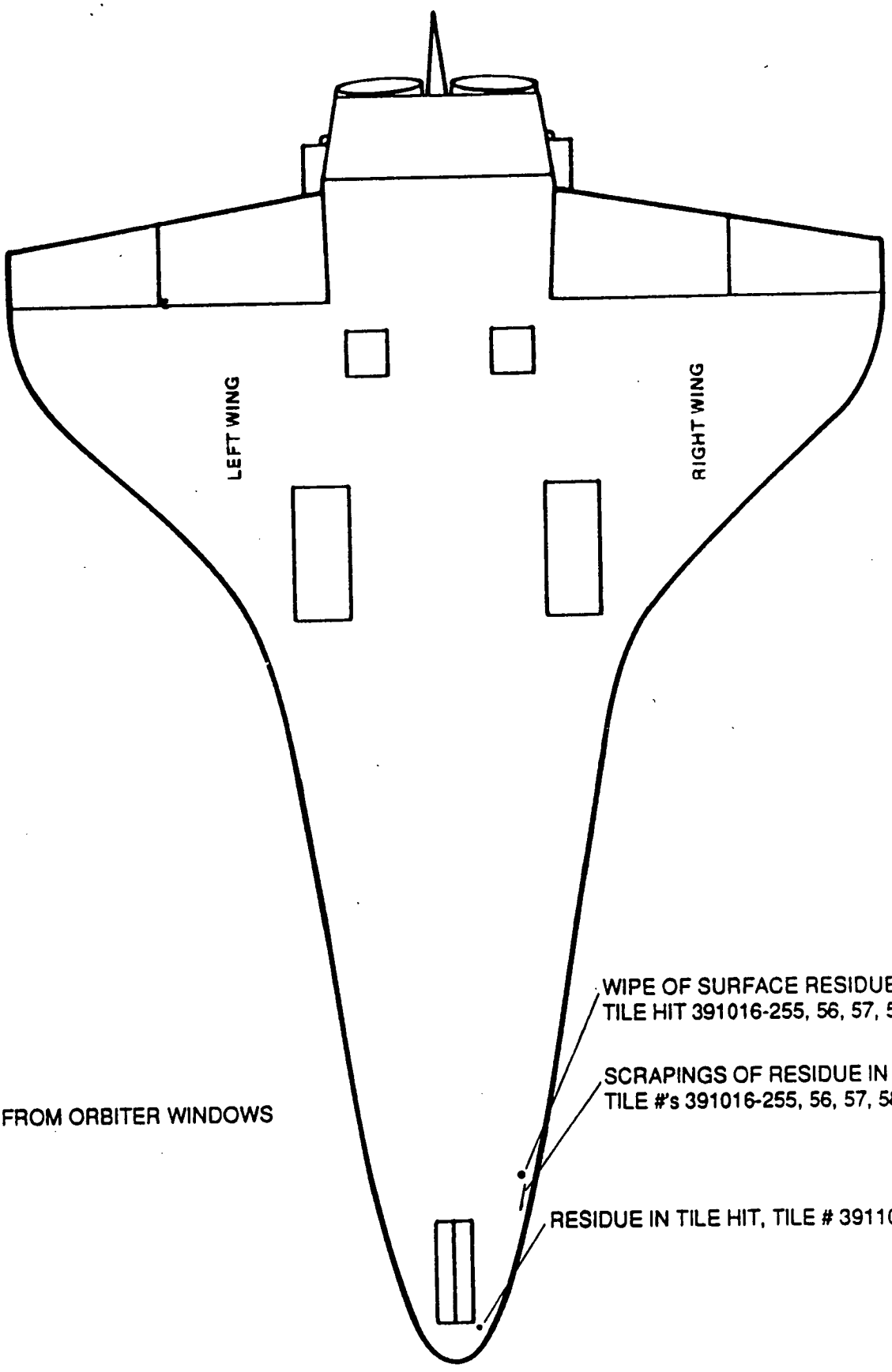
White streaks were present on the RH wing leading edge RCC panels and appeared similar to streaks observed after previous landings.

Orbiter windows #3 and #4 exhibited moderate to heavy hazing with a few small streaks. Windows #1, #2, #5, and #6 had light to moderate hazing with several small streaks. There was no evidence that the haze on the windows was the result of flight through volcanic ash. Figure 19 shows the sites on the Orbiter where samples were taken for laboratory analysis.

A piece of thermal barrier approximately 8 inches in length was missing from the right side of the forward RCS module between thrusters F2R and F4D. The thermal barrier on the left side of the forward RCS module between thrusters F1L and F3D was frayed and a 4-inch section was protruding.

FIGURE 19. **STS-43**

CHEMICAL SAMPLE LOCATIONS



No tiles, carrier panels, or other TPS materials were missing from the Orbiter that would account for the debris object observed on-orbit after the TDRSS/IUS deployment. Frozen oxygen from the SSME area is the most likely explanation for that object.

The Mikron infrared radiometer was used to measure the surface temperatures of several areas on the Orbiter. Eighty-four minutes after landing, the nosecap RCC was 113 degrees F, the RH wing leading edge RCC panel #9 was 92 degrees F, and the RH wing panel #17 was 91 degrees F (Figure 20).

In summary, the total number of Orbiter TPS debris hits and the number of hits with a major dimension of one inch or larger was near average as shown in the comparison charts (Figure 21-23). The distribution of hits on the Orbiter does not point to a single source of ascent debris, but indicates a shedding of ice and TPS debris from random sources.

Orbiter Post Landing Anomalies are listed in Section 11.

FIGURE 20. **STS-43**

TEMPERATURE MEASUREMENTS

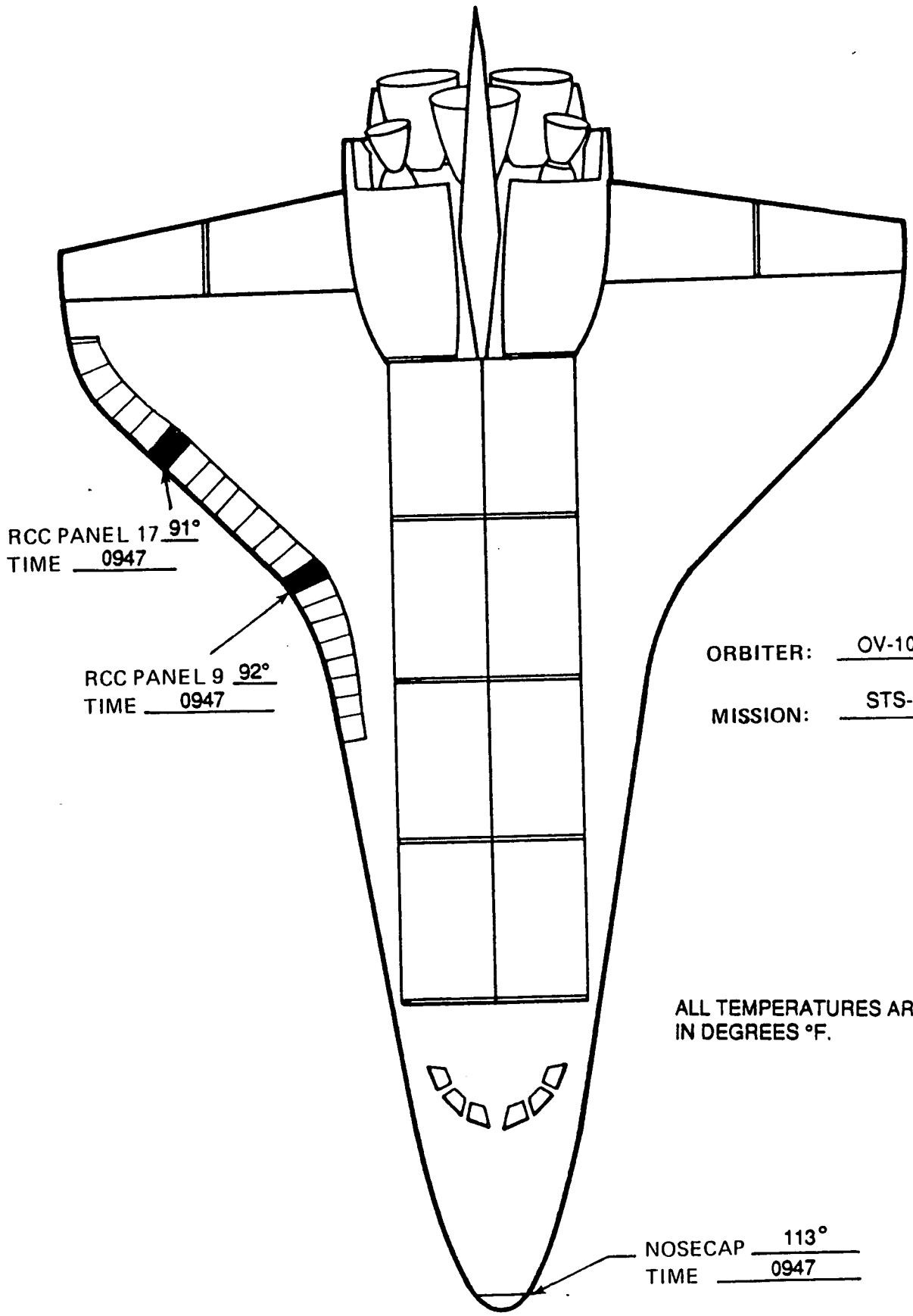


FIGURE 21: POST FLIGHT DEBRIS DAMAGE SUMMARY

	> 1 INCH	TOTAL
STS-6	36	120
STS-8	7	56
STS-9	14	58
STS-11	34	63
STS-13	8	36
STS-14	30	111
STS-17	36	154
STS-19	20	87
STS-20	28	81
STS-23	46	152
STS-27	33	141
STS-28	17	111
STS-30	34	183
STS-31	55	257
STS-32	39	193
STS-29	23	132
STS-28R	20	76
STS-34	18	53
STS-33R	21	118
STS-32R	15	120
STS-36	19	81
STS-31R	14	63
STS-41	16	76
STS-38	8	81
STS-35	17	147
STS-37	10	113
STS-39	16	238
STS-40	25	197
STS-43	25	131
AVERAGE	23.6	118.2
SIGMA	11.8	55.8

SINCE RETURN TO FLIGHT	
> 1 INCH	TOTAL
23	132
20	76
18	53
21	118
15	120
19	81
14	63
16	76
8	81
17	147
10	113
16	238
25	197
25	131
17.6	116.1
5.1	52.1

THIS ANALYSIS DOES NOT INCLUDE STS-24, 25, 26, 26R, 27R, AND 30R
THESE MISSIONS HAD DAMAGE CAUSED BY KNOWN SOURCES

FIGURE 22. # COMPARISON TABLE

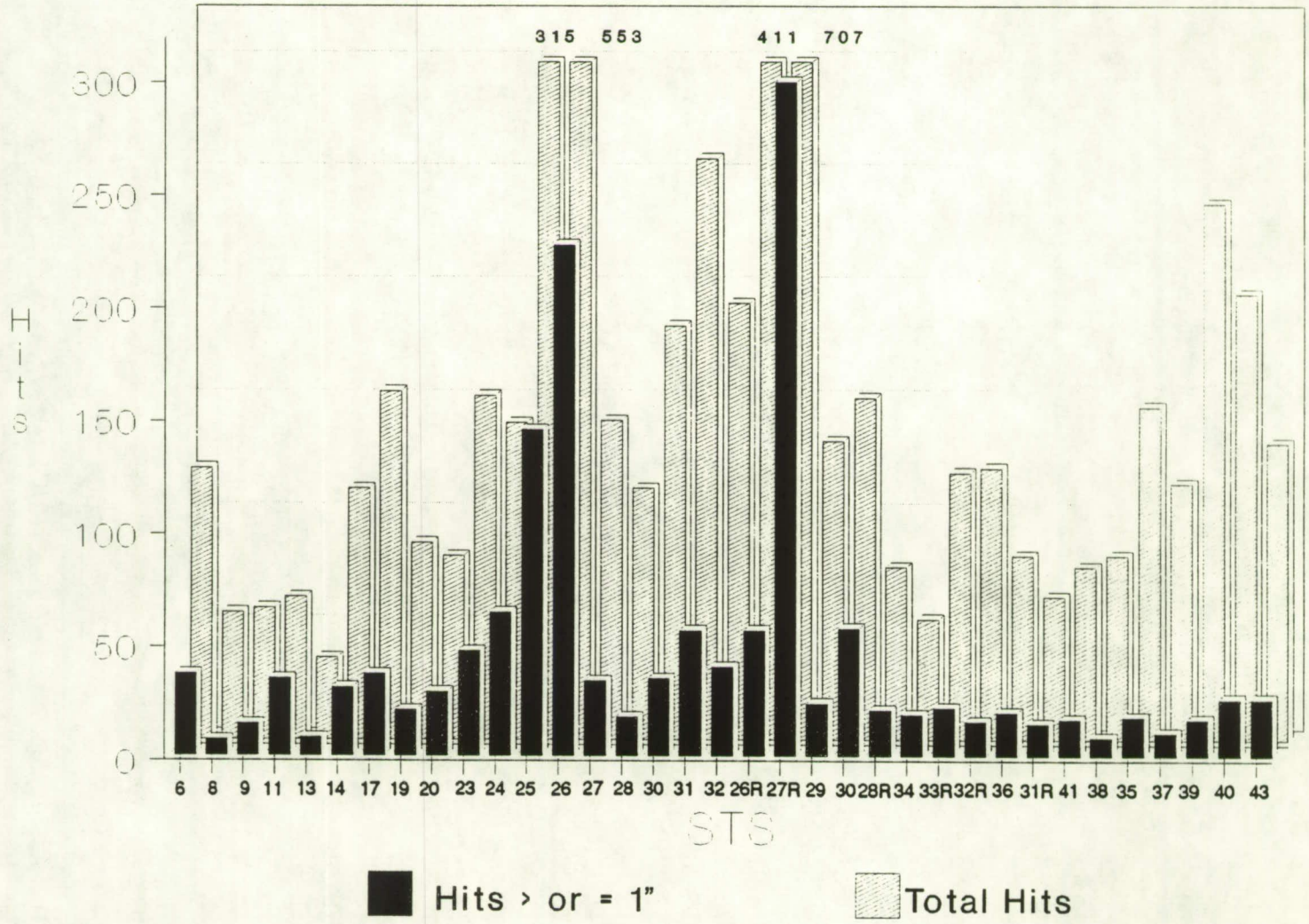


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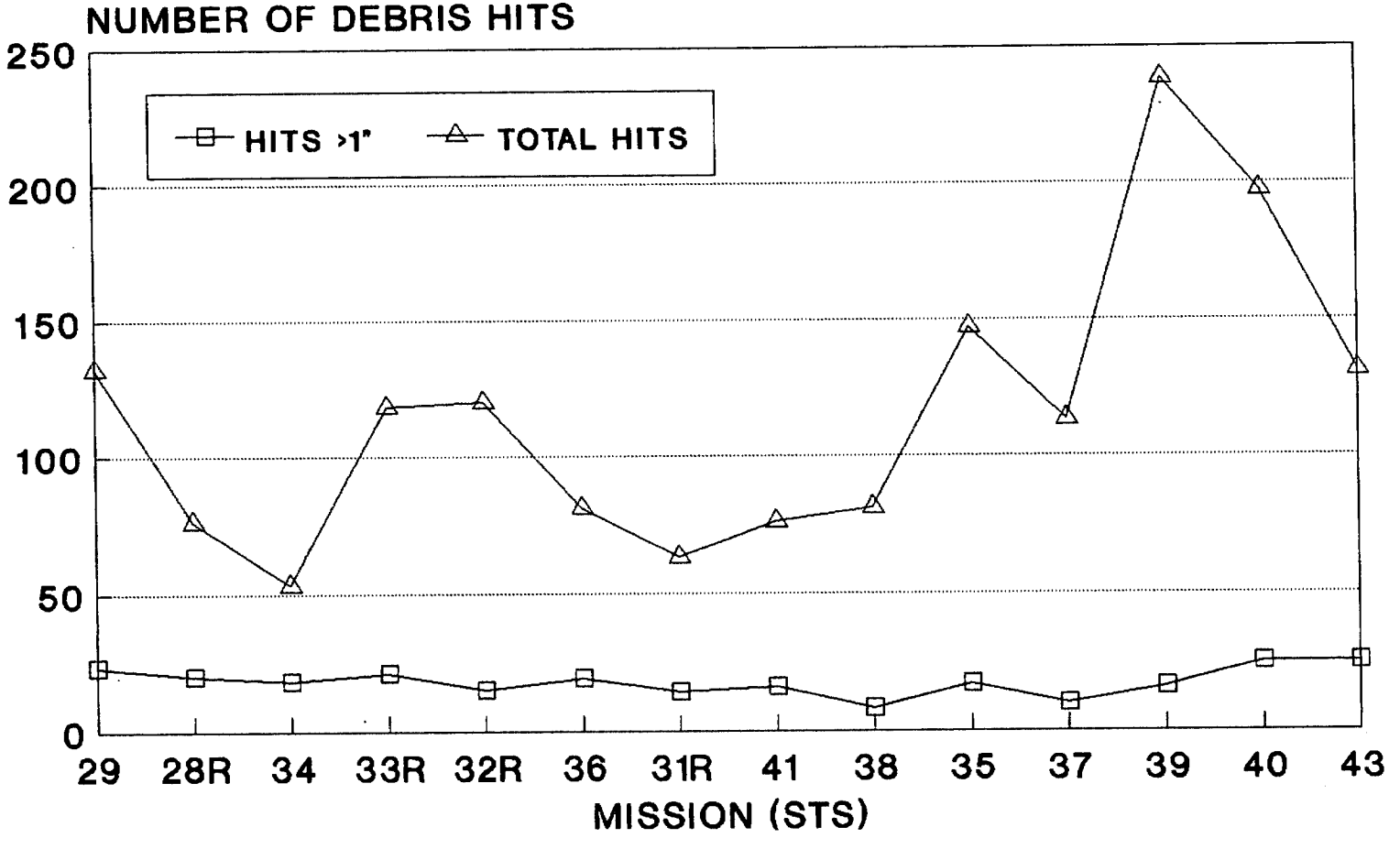
FIGURE 23.

ORBITER TPS DEBRIS DAMAGE
STS-29 THROUGH STS-43



AVERAGES: > 1" = 17.6, TOTAL = 116.1

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OV-104 Atlantis made the 8th landing at the Kennedy Space Center on Runway 15 August 11, 1991

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Overall view of OV-104 right side after landing

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COLOR PHOTOGRAPH

Overall view of OV-104 left side after landing

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COLOR PHOTOGRAPH

Overall view of OV-104 nose/windows after landing

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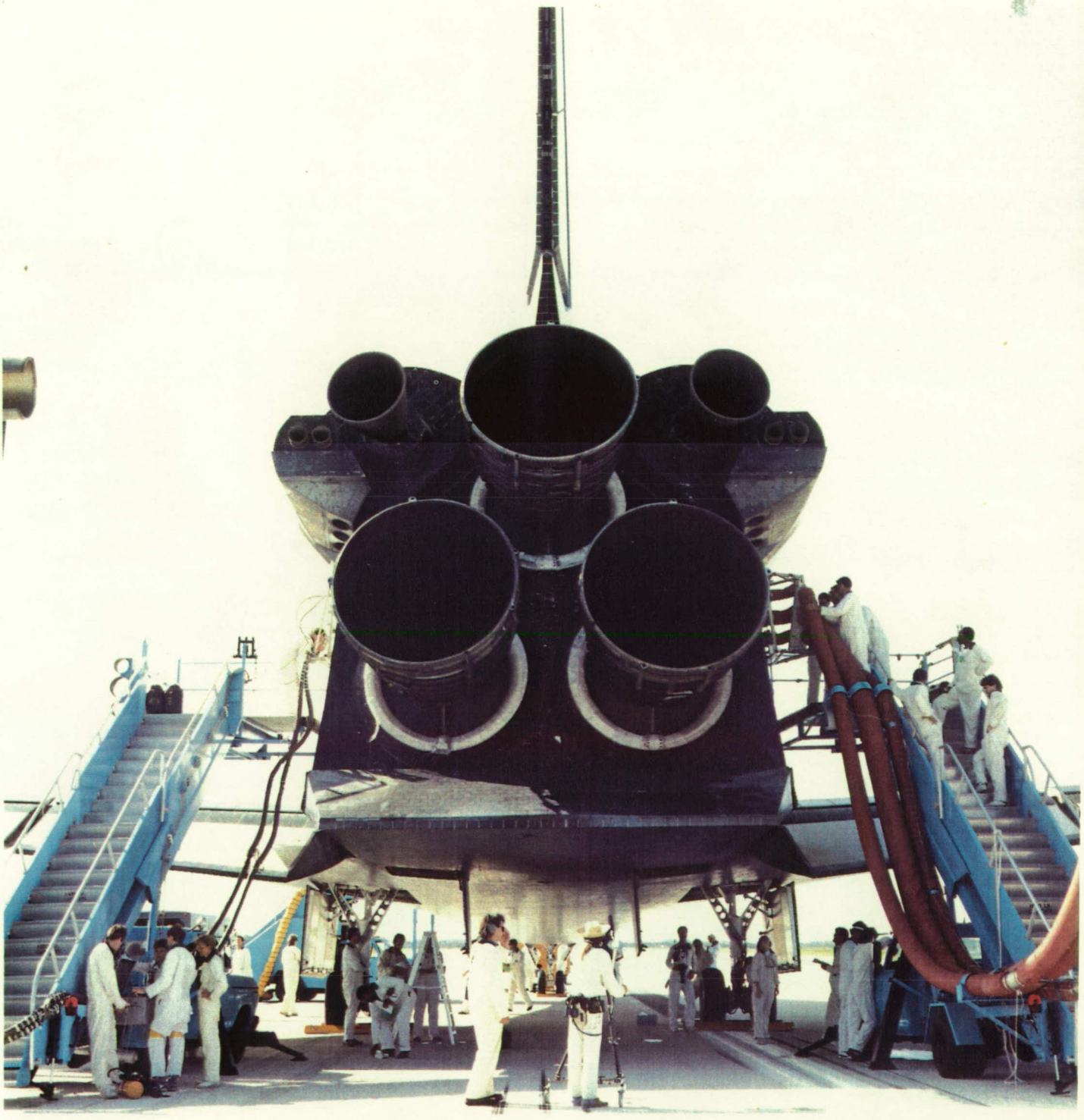
COLOR PHOTOGRAPH



Overall view of SSME's and base heat shield. Note missing tile fragment from base heat shield inboard of SSME #3.

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The largest single tile damage site on the Orbiter lower surface occurred on the RH nose area below the forward RCS module and measured approximately 18" x 1" x 1/8" (spanned 6 tiles). This shallow hit is indicative of damage typically caused by low density material, such as ET SOFI.

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A cluster of 19 hits (with 7 larger than one inch) occurred just forward of the LO2 ET/ORB umbilical.

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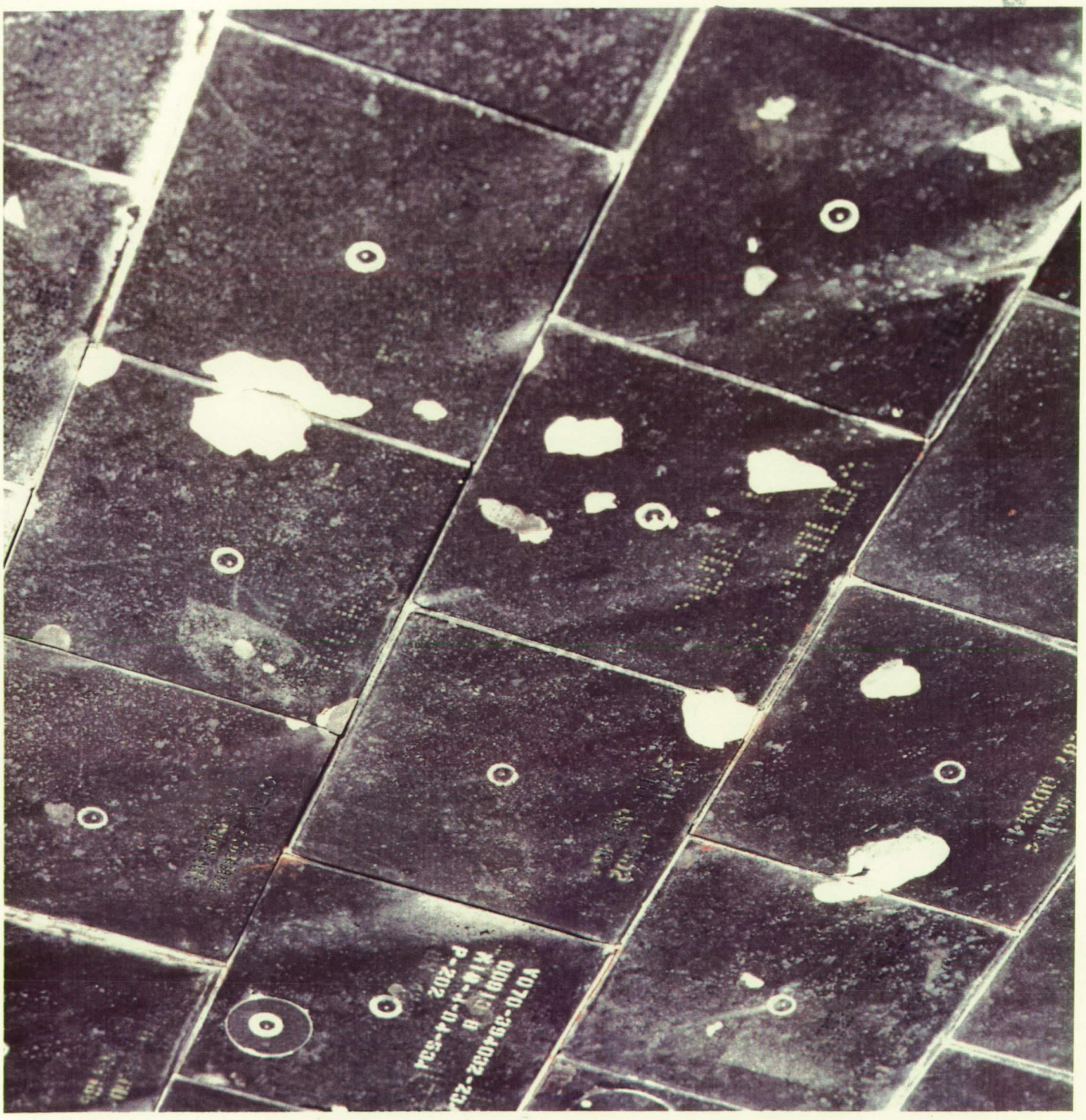

Similar tile damage have been observed forward of the LO2 ET/ORB umbilical on previous flights and may be attributed to ice from the LO2 feedline bellows and support brackets.

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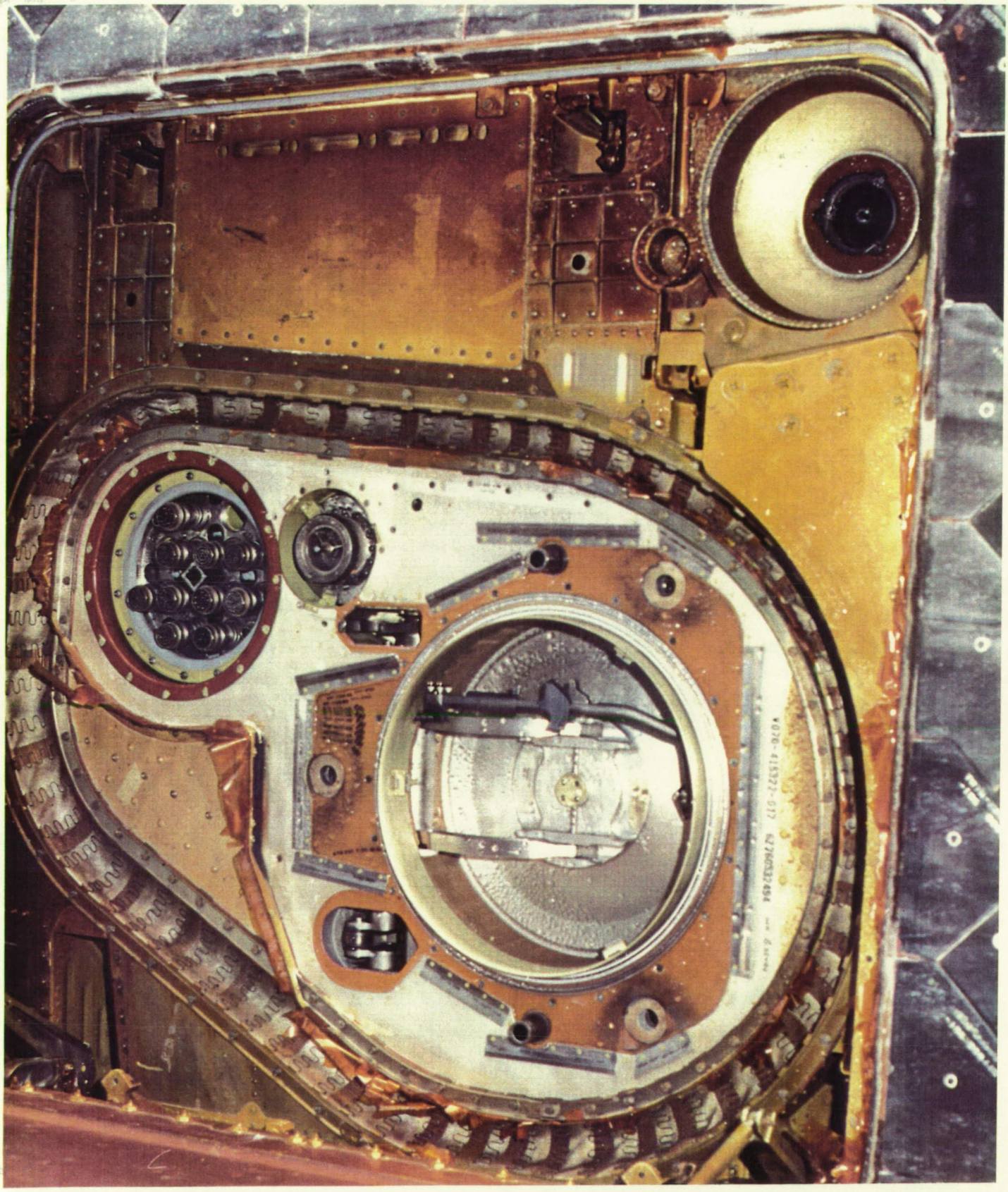

Overall view of the LO2 ET/ORB umbilical. The separation ordnance device debris plunger in EO-3 was seated and appeared to have functioned properly. There was no significant heat intrusion past the ET door thermal barrier.

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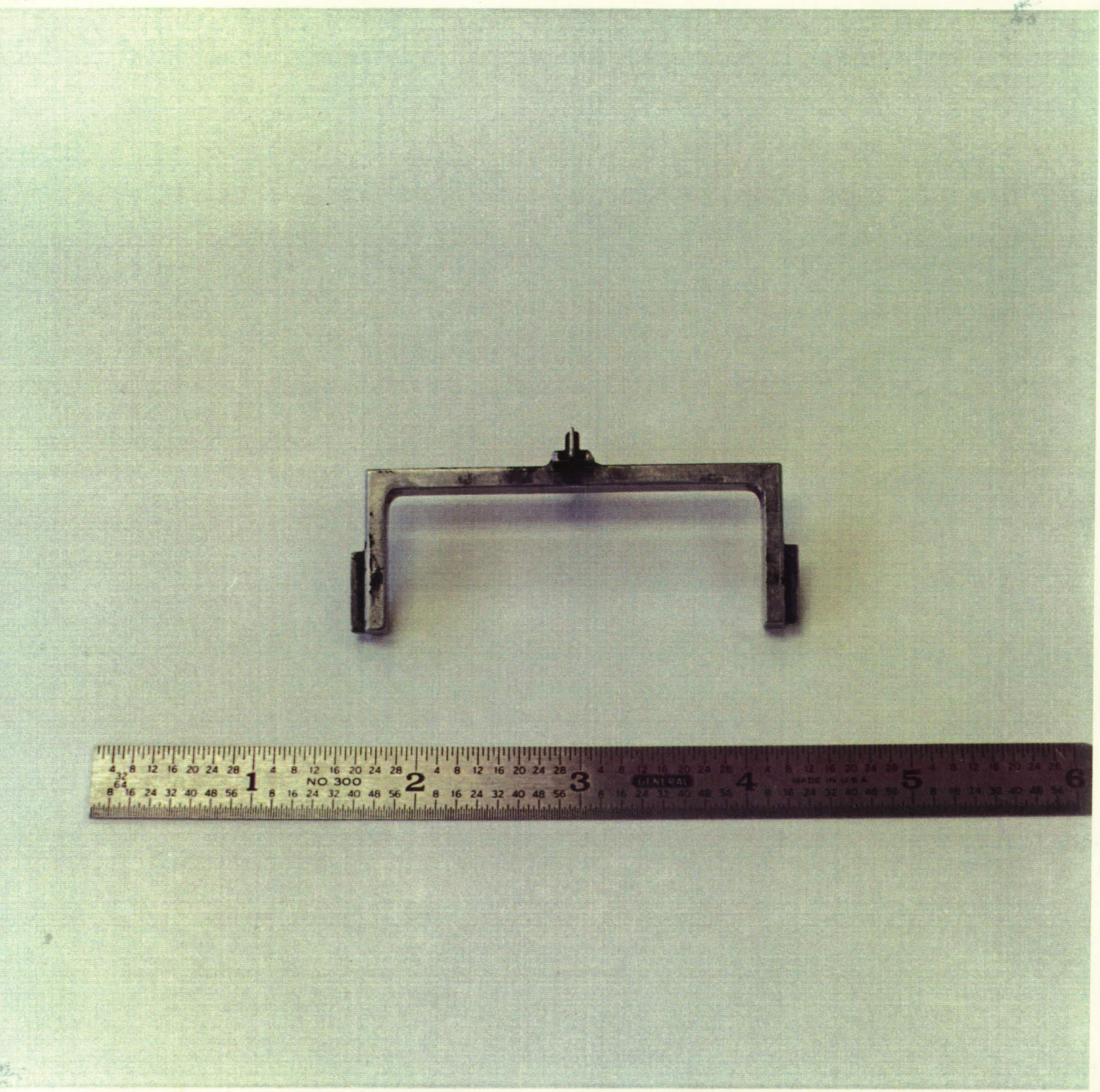

A metallic U-shaped object, identified as a V072-565471-001 yoke, was found on the runway beneath the LO2 ET/ORB umbilical and originated from the forward inboard umbilical separation bolt head.

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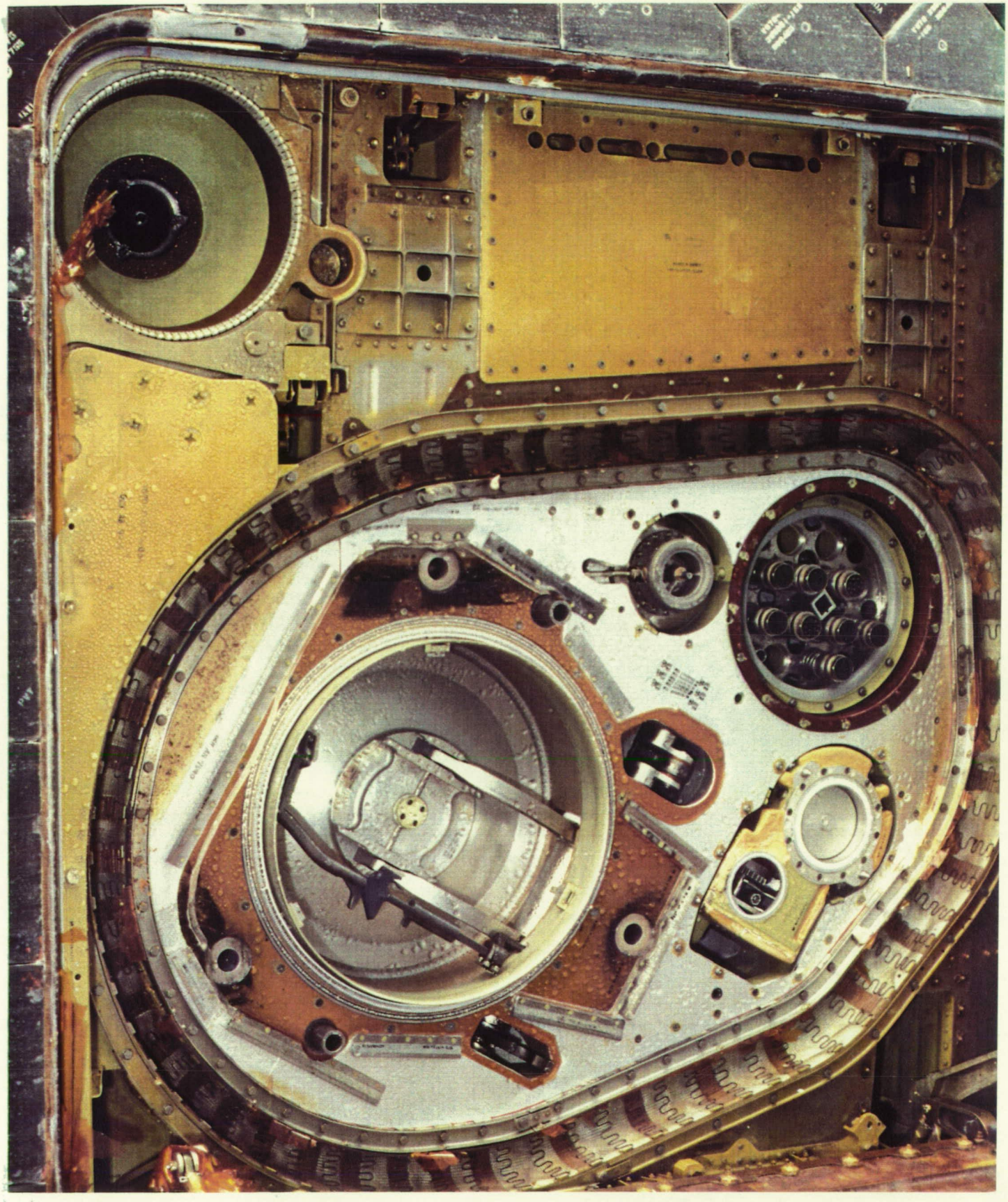

Overall view of the LH2 ET/ORB umbilical. The separation ordnance device debris plunger in EO-2 was seated and appeared to have functioned properly. There was no significant heat intrusion past the ET door thermal barrier.

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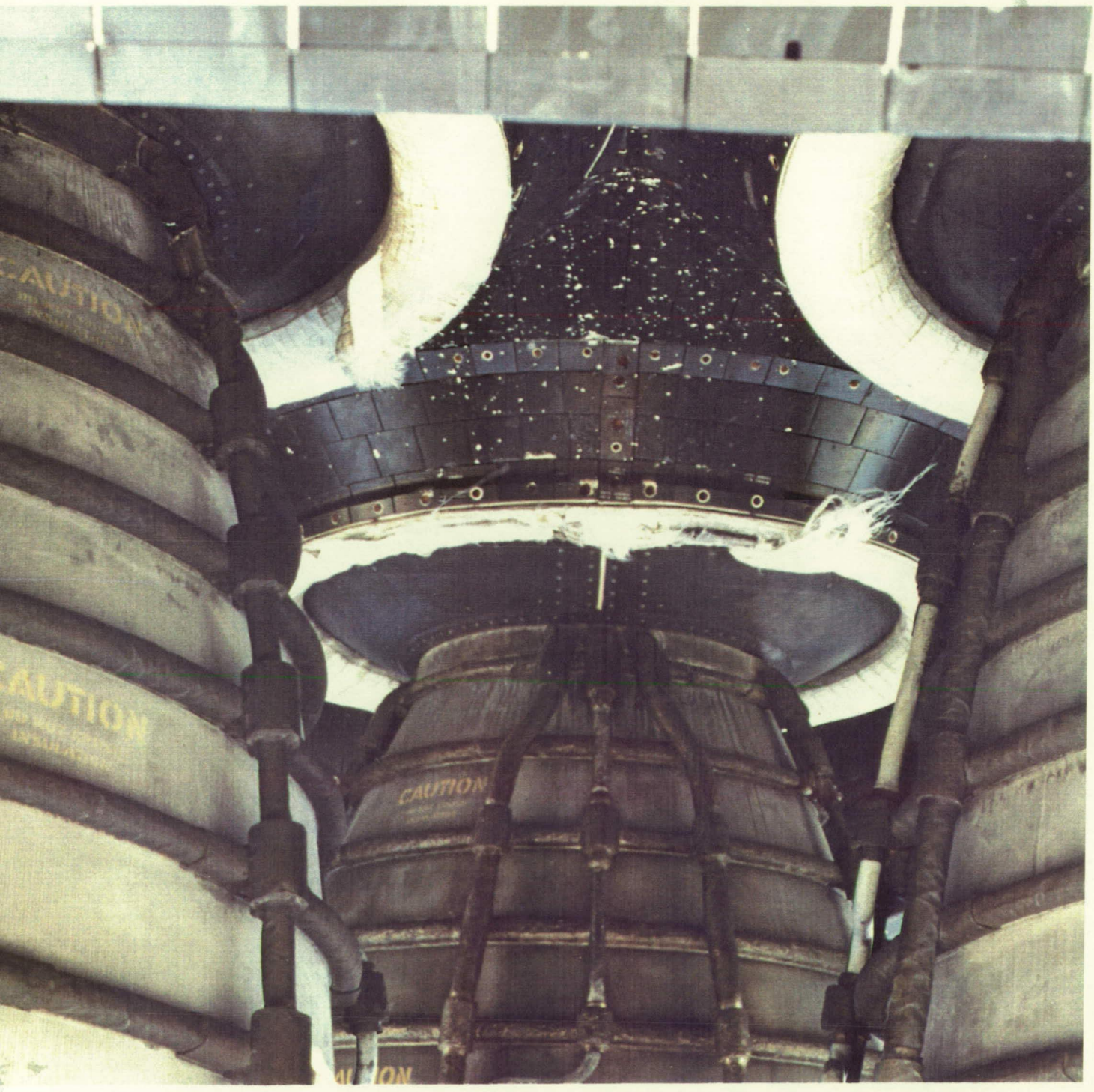

Damage to the base heat shield tiles was average. The outer layer of SSME #3 closeout blanket was peeled back along a 12 inch length at the 10:00 o'clock position. SSME #1 closeout blanket was missing numerous layers of material from the 4-7:00 o'clock position and may have been the white object observed in films falling aft of the Orbiter 43 seconds after launch.

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White streaks were present on the RH wing leading edge RCC panels and appeared similar to streaks observed after previous landings.

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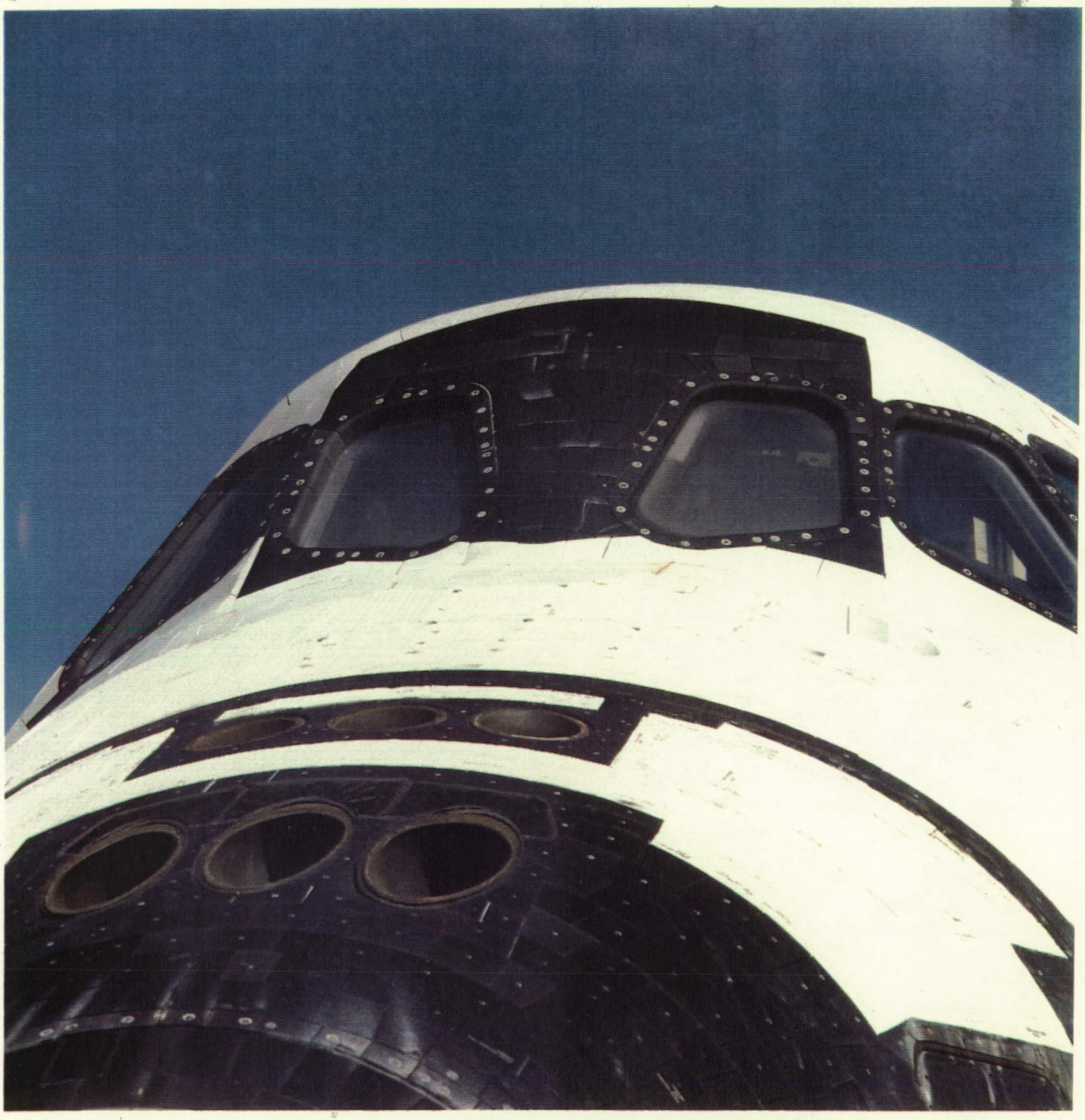

Orbiter windows #3 and #4 exhibited moderate to heavy hazing with a few small streaks. The remaining windows had light to moderate hazing with several small streaks.

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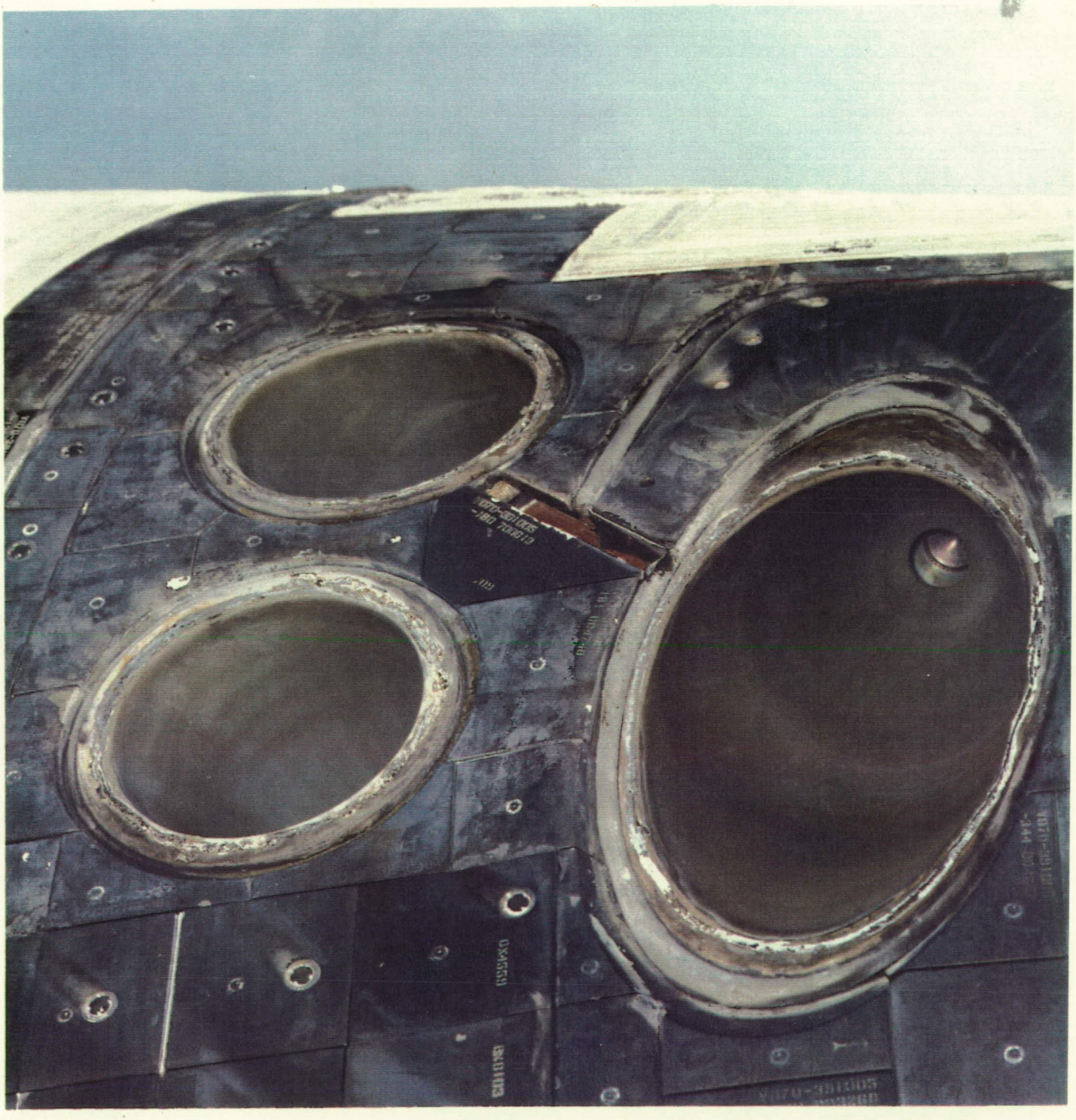

A piece of thermal barrier approximately 8 inches in length was missing from the right side of the forward RCS module between thrusters F2R and F4D.

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The thermal barrier on the left side of the forward RCS module between thrusters F1L and F3D was frayed and a 4 inch section was protruding.

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10.0 DEBRIS SAMPLE LAB REPORTS

A total of 12 samples were obtained from Orbiter OV-104 during the STS-43 post landing debris assessment at Kennedy Space Center, Florida (Figure 19). The 12 submitted samples consisted of 8 Orbiter window wipes (W1-8), 3 tile residue samples, and 1 debris sample from the runway. The samples were analyzed by the NASA KSC Microchemical Analysis Branch (MAB) for material composition and comparison to known STS materials. The specific elemental analysis is shown in the appended MAB report. Debris analysis involves the placing and correlating of particles with respect to composition, thermal (mission) effects, and availability. Debris sample results and analyses are listed by Orbiter location in the following summaries.

Orbiter Windows

Results of the window sample analysis indicated the presence of the following materials:

1. Metallic particles
2. RTV, glass fibers and insulation
3. Cerium-rich materials
4. Paint, rust and salt
5. Organics
6. Earth compounds

Debris analysis provides the following correlations:

1. Metallic particles (aluminum, stainless and carbon steel) are common to SRB/BSM exhaust residue, but are not considered a debris concern in this quantity (micrometer) and have not generated a known debris effect.

2. RTV, glass fibers and insulation originate from Orbiter TPS (thermal protection system).

3. Cerium-rich material originates from Orbiter window polishing compounds.

4. Paint is of flight hardware/facility/GSE origin; rust is an SRB/BSM exhaust residue; and salt is a naturally-occurring landing site product.

5. Organics were found to be cellulose, protein, sucrose, and nylon (adhesive/proteinaceous origin); urethane (as foam); and cellulose fibers (sample cloth origin).

6. Earth compounds (Aluminum-Silica-Calcium rich material, calcite, alpha-quartz, Silica-Calcium rich material) are of landing site origin.

Orbiter Tile

Results of the tile sample chemical analysis revealed the presence of the following materials:

1. RTV, black and white silicon-rich tile
2. Metallics and rust
3. Organics and paint
4. Salt and earth compounds

Debris analysis provides the following correlations:

1. RTV, black and white silicon-rich tile fibers originate from the Orbiter thermal protection system (TPS).
2. Metallics and rust originate from SRB/BSM exhaust residue.
3. Organics (cellulose, protein, sucrose, nylon) are of adhesive/proteinaceous origin, cellulose fibers are of sample cloth origin; paint is of flight hardware/GSE/ facility origin.
4. Salt and earth compounds (aluminum-silica-calcium and silica-calcium rich materials) are of landing site origin.

Debris from Runway

Results of the runway debris sample analysis indicated the presence of the following materials:

1. Orbiter TPS
2. Metallics and rust
3. Organics and paint
4. Salt and earth compounds
5. White film composed of silicone polymer (elastomer) with titanium dioxide and silicon dioxide

Debris analysis provides the following correlations:

1. Orbiter TPS materials (RTV, black and white tile, and insulation glass) originate from Orbiter TPS (thermal protection system).
2. Metallics and rust originate from SRB/BSM exhaust residue.

3. Organics (cellulose, protein, sucrose, nylon) are of adhesive/proteinaceous origin, cellulose fibers are of sample cloth origin; paint is of flight hardware/GSE/ facility origin.

4. Salt and earth compounds (aluminum-silica-calcium and silica-calcium rich materials) are of landing site origin.

5. White film appears to be paint, but not of known Space Shuttle Program/element origin.

Conclusions

The STS-43 mission sustained slightly greater than average Orbiter tile TPS damage. The chemical analysis results of post flight samples did not provide data that points to a single source of damaging debris.

Samples from the Orbiter windows contained SRB/BSM exhaust residuals, Orbiter thermal protection system (TPS) materials, Orbiter window polishing compound residuals, paint and organic materials, and earth compounds. Also noted was the presence of urethane (as foam) whose source could not be resolved due to the small amount of the sample.

The Orbiter tile sample results provided indications of thermal protection system (TPS) residual material. The variety and trace amounts of non-TPS material did not provide a single source debris anomaly.

The sample recovered from the Shuttle Landing Facility (SLF) runway was found to be a "paint-like" film substance that did not resemble a known material in the Shuttle Program. The sample did indicate similar residual materials as detected in other post flight samples. Additional material testing will be performed to identify the source of this "paint-like" debris.

The sample quantity for this mission (fewer than normal) was proportional to the residuals evident on the Orbiter. Also noteworthy was the commonality of material in the samples. These factors exponentially increase the difficulty of debris damage source evaluation.

11.0 POST LAUNCH ANOMALIES

Based on the debris inspections and film review, 10 Post Launch Anomalies, including one IFA candidate, were observed on the STS-43 mission.

11.1 LAUNCH PAD/FACILITY

1. Typical damage to the facility included 1) four FSS level signs detached from the west side of the elevator shaft, 2) a panel detached between elevator doors on the 115' level, 3) cabinet doors were ajar and bent, 4) one cable tray cover was found 100 yards east of the pad, and 5) one of nine light fixtures from an east stadium light was detached and found east of the pad. (KSC Pad turnaround item)

2. The MLP-1 deck southwest rainbird did not activate at T-0. No water was visible exiting the rainbird as the vehicle cleared the tower and SRB plume obscured the rainbird. (KSC Pad turnaround item)

11.2 EXTERNAL TANK

1. No items.

11.3 SOLID ROCKET BOOSTERS

1. Launch films confirmed a stud hang-up on HDP #7. The stud pulled loose EPON shim material, three small pieces adjacent to the stud hole, from the aft skirt foot. No ordnance fragments fell from the HDP #7 DCS/stud hole. Post flight inspection revealed the HDP #7 stud hole was broached. (SRB project item)

2. Three ordnance fragments fell from the HDP #2 DCS/stud hole shortly after liftoff (film item E-8). Post flight inspection revealed the HDP #2 DCS plunger was obstructed by a frangible nut half. One dark, thin object, possibly a frangible nut web or piece of firing cable, fell between the doghouse blast cover and the HDP #8 shoe (E-14). (SRB project item)

3. The RH frustum was missing no TPS but had 46 MSA-2 debonds over fasteners. The LH frustum exhibited no missing TPS but had 38 MSA-2 debonds over fasteners. MSA-2, 2.5"x1" in size, was missing from the LH forward skirt near the +Z RSS antenna. (SRB project item)

4. A 5"x2.5" piece of EPON shim material was missing from the HDP #4 aft skirt foot prior to water impact. The shim material should remain bonded during flight. (SRB project item)

11.4 ORBITER

1. Tile surface coating material was lost from the aft face of the LH OMS pod near the OMS nozzle, the body flap +Z side, one location on the base heat shield near SSME #2, and two locations near the LH OMS nozzle. More coating material was lost from six locations near the RH OMS nozzle and two locations on the base heat shield near SSME #3. Loss of the coating typically occurs during SSME ignition. (Orbiter project item)

2. Numerous flashes and discolorations, possibly caused by contaminants or impurities, were visible in the SSME #2 Mach diamond during ignition. (Orbiter project item)

3. The SSME #1 closeout blanket was frayed and missing numerous layers of material at the 4-7 o'clock location. Film analysis showed a white object originating from an area between SSME #1/#2 and falling aft of the Orbiter at T+43 seconds. The most likely candidate for the white object is a piece of the SSME #1 closeout blanket. The larger-than-usual area of blanket damage and loss of the material early in flight is unusual. (Orbiter IFA candidate)

4. A yoke from the LO2 ET/ORB umbilical separation bolt head, part number V072-565471-001, was found on the runway beneath the LO2 ET door. The metallic, U-shaped yoke measured 2.75" x 1.0" x 0.937". The yoke should have remained in the debris container. (Orbiter project item)

APPENDIX A.

MICROCHEMICAL ANALYSIS BRANCH
DM-MSL-1, ROOM 1274, O&C BUILDING
NASA/KSC
OCTOBER 1, 1991
ADDENDUM

SUBJECT: Debris And Orbiter Residue Samples

LABORATORY REQUEST NO: MCB-0609-91 ADDENDUM

RELATED DOCUMENTATION: Intercenter Debris Team Requirements

1.0 FOREWORD:

1.1 REQUESTER: R. F. Speece/TV-MSD-22/1-3635

1.2 REQUESTER'S SAMPLE DESCRIPTION: The samples were from KSC SLF, OV-104, STS-43 landing KSC, and were identified as:

I. Window Wipe
1. window #1
2. window #2
3. window #3
4. window #4
5. window #5
6. window #6
7. window #7
8. window #8

II. Runway
9. debris from runway, post-landing

III. Tile Debris
10. wipe from AFT of 5 tile hit
11. black specs from 5 tile hit, 391016-255
12. black specs 3911036-633

1.3 REQUESTED: Perform material analysis and compare results to known STS materials.

2.0 CHEMICAL ANALYSIS AND RESULTS:

2.1 Procedure:

The samples were analyzed by means of optical microscopy (OM), infrared spectrometer (IRS), and electron microprobe with energy dispersive spectrometry (EDS).

2.2 Results:

2.2.1 The particulates were classified into components on the basis of color and texture by OM. The classified components from each sample are listed in Table 1 with elemental analysis.

Table 1

Component ID	Elemental Analysis by EDS*	
	Major	Minor
1.Metallics	Fe,Cr,Al,Cu,Zn	Ni
2.Red rust	Fe,Si,Cl,Ce,Al	Ti,Ca,S,Mg,Zn
3.Red rubbery	Fe,Si	
4.Blk mtls	Si,Fe,Cr,Al,P,S,Cl	K,Zn,Al,Ca
5.Blk rubbery	Zn,Ca,Si,S,organics	Al,Fe
6.Grn mtls	Ni,Si,Ca,S,Cl	Al,Fe,Zn,Cr
7.Yellow mtls	Pb,S,Fe,Cr,Ti	Al,Si
8.Grey mtls	Si,Al	
9.Wht mtls	Na,Cl,Ti,Si,Ca,S	organics,Fe,Al,Mg
10.Alpha-quartz	Si	
11.Blk dense tile	Si	
12.Wht dense tile	Si	
13.Blk spheres	Fe	
14.Glass fibers	Si,Al	
15.Organics	cellulose,protein,urethane,nylon,sucrose, ester	
16.Organic fiber	cellulose fiber	

*: O, C, H, and B are not detectable by using this technique.

2.2.2 Table 2 lists estimated amounts of each component versus sample number.

Table 2

Sample No Components	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1.Metallics	T	T	1	T	T	3	T	x	T	T	x	x
2.Red rust	10	2	8	T	3	T	1	T	x	2	x	x
3.Red rubbery	x	x	x	T	T	x	x	x	x	x	x	x
4.Blk mtls	20	12	18	8	6	8	8	10	10	10	x	x
5.Blk rubbery	8	1	x	x	x	x	x	x	x	x	x	x
6.Grn mtls	1	1	x	x	x	T	x	x	x	x	x	x
7.Yellow mtls	x	x	T	x	x	x	x	x	x	x	x	x
8.Grey mtls	x	23	2	25	29	x	x	x	x	T	x	x
9.Wht mtls	8	8	17	30	26	35	15	15	30	15	x	x
10.Alpha-quartz	15	5	8	8	10	15	8	30	5	x	x	x
11.Blk dens tile	x	x	x	x	x	x	x	x	x	x	5	2
12.Wht tile	x	x	5	x	x	x	x	x	x	45	95	98
13.Blk spheres	x	T	T	T	T	T	T	T	T	x	x	x
14.Glass fibers	T	T	T	x	x	x	T	1	x	T	x	x
15.Organics	37	48	41	29	26	39	68	44	35	28	x	x
16.Organic fiber	1	T	T	T	T	T	T	T	20	T	x	x
Particle size in um	1-200	1-350	1-300	1-280	1-250	1-400	1-250	1-250	1-220	1-500	L	L

10: Estimated Volume Percent. T: Trace.
x: Not Detected. L: Large, <2000 um

3.0 CONCLUSIONS:

3.1 All samples contained small amounts of particulates and the particulates were composed of metallics, red materials, red rubbery materials, black materials, black rubbery materials, green materials, yellow materials, grey materials, white materials, alpha-quartz, black dense tile, white tile, black spheres, glass fibers, organics, and organic fibers.

3.2 The following samples contained metallics :

1. Al-alloy, 300 series stainless steel, and brass
2. Zn-metal, Al-alloy, and Ce-materials
3. Al-alloy and Zn-alloy
4. Al-alloy
5. Al-alloy
6. Al-alloy
7. Al-alloy and 300 series stainless steel
9. carbon steel
10. Al-alloy and 300 series stainless steel

3.3 The sample numbers 1 through 8 and 10 contained red rust , and samples 2, 3, 4, 5, and 8 contained Ce rich materials.

3.4 The sample numbers 4 and 5 contained RTV.

3.5 The sample numbers 1 through 10 contained black materials. The black materials appeared to be composed of Si rich materials, Fe-rich materials, Al-Si-Ca rich materials, rust, and salt.

3.6 The sample numbers 1 and 2 contained black rubbery materials. The black rubbery materials appeared to be composed of silicone or urethane.

3.7 The sample numbers 1, 2, and 6 contained green materials The green materials were composed of Ni-Ca-S-Cl rich materials and Si-Ca rich materials.

3.8 The sample number 3 contained yellow paint chips.

3.9 The sample numbers 2, 3, 4, 5, and 10 contained grey materials. The grey materials were composed totally of Si-Al rich materials which could be a part of high temperature insulation.

3.10 The sample numbers 1 through 10 contained white materials. The white materials appeared to be composed of Si-rich materials, calcite ($CaCO_3$), paints, and salts

3.11 The sample numbers 1 through 9 contained alpha-quartz (alpha-SiO_2).

3.12 The sample numbers 11 and 12 contained black dense tile and white fibrous tile materials.

3.13 The sample numbers 2 through 9 contained trace amounts of black carbon steel spheres.

3.14 The sample numbers 1, 2, 3, 7, 8, and 10 contained Si-Al rich high temperature insulation type fibers.

3.15 The sample numbers 1 through 10 contained organics. The organics were identified to be cellulose, protein, urethane, nylon, sucrose, and ester.

3.16 The sample numbers 1 through 10 contained cellulose organic fibers.

3.17 The particle sizes were estimated to be in the range of 1 to 500 micrometers.

INVESTIGATOR: H. S. Kim
H. S. Kim

INVESTIGATOR: W R Carman
W. R. Carman

APPROVED: for J. F. Jones

NASA
National Aeronautics and Space Administration

Report Documentation Page

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Gregory N. Katnik
Scott A. Higginbotham
James Bradley Davis

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Mail Code: TV-MSD-22
Kennedy Space Center, Florida 32899

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15. Supplementary Notes

16. Abstract

A Debris/Ice/TPS assessment and photographic analysis was conducted for Space Shuttle Mission STS-43. Debris inspections of the flight elements and launch pad were performed before and after launch. Ice/frost conditions on the External Tank were assessed by the use of computer programs, nomographs, and infrared scanner data during cryogenic loading of the vehicle followed by on-pad visual inspection. High speed photography was analyzed after launch to identify ice/debris sources and evaluate potential vehicle damage and/or in-flight anomalies. This report documents the debris/ice/TPS conditions and photographic analysis of Mission STS-43, and their overall effect on the Space Shuttle Program.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
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